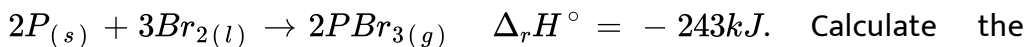# CHEMISTRY

BOOKS - P BAHADUR CHEMISTRY (HINGLISH)

THERMOCHEMISTRY

Exercise 1

1. Red phosphorus reacts with liquid bromine in an exotermic reaction :

$$2P_{(s)} + 3Br_{2(l)} \rightarrow 2PBr_{3(g)} \quad \Delta_r H^\circ = -243kJ.$$ Calculate the enthalpy change when $2.63g$ of phosphorus with an excess of bromine in this way.

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Exercise 2

1. Ammonium nitrate can decompose with explosion by the following reaction :

$NH_4NO_{3(s)} \rightarrow N_2O_{(g)} + 2H_2O_{(g)}, \Delta H = -37.0kJ$ Calculate the heat produced when $2.50g$ of NH_4NO_3 decomposes.

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Exercise 3

1. Heat of reaction for $C_6H_{12}O_{6(s)} + 6O_{2(g)} \rightarrow 6CO_{2(g)} + 6H_2O_v$ at constant pressure is $-651kcal$ at $17°C$. Calculate the heat of reaction at constant volume at $17°C$.

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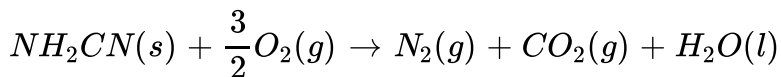**Exercise 4**

1. The enthalpy change (ΔH) for the reaction,

$NH_{2(g)} + 3H_{2(g)} \rightarrow 2NH_{3g}$ is $-92.38kJ$ at $298K$ What is ΔU at $298K$?

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Exercise 5

1. The reaction:

$$NH_2CN(s) + \frac{3}{2}O_2(g) \rightarrow N_2(g) + CO_2(g) + H_2O(l)$$

Was carried out in a bomb caloriemeter. The heat released was $743kJmol^{-1}$. The value of ΔH_{300K} for this reaction would be

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Exercise 6

1. ΔH_f° for HgO is $-21.7kcal/mol$ at $25^\circ C$. Calculate the mass of mercury which can be liberated by treatment of excess of HgO with $10.0kcal.\ At.\ Wt.$ of $Hg = 200.6$.

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Exercise 7

1. ΔH_f° for Al_2O_3 is $-1670kJ$. Calculate the enthalpy change for the reaction: $4Al + 3O_2 \rightarrow 2Al_2O_3$.
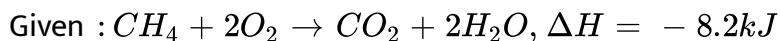
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Exercise 8

1. The specific heats of iodine vapour and solid are 0.031 and $0.055cal/g$ respectively. If heat of sublimation of iodinde is $24cal/g$ at $200^\circ C$, what

is its value at $250°C$?

Enthalpy Change

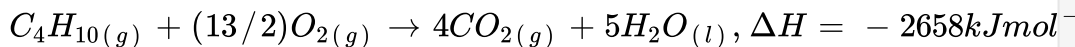**1.** How much heat is produced when $4.50g$ methane gas is burnt in a constant pressure system ?

Given : $CH_4 + 2O_2 \rightarrow CO_2 + 2H_2O$, $\Delta H = -8.2kJ$

2. A cooking gas cylinder is assumed to contain $11.2kg$ isobutane. The combustion of isobutane is given by :

$C_4H_{10(g)} + (13/2)O_{2(g)} \rightarrow 4CO_{2(g)} + 5H_2O_{(l)}$, $\Delta H = -2658kJmol^{-}$

(a) If a family needs $15000kJ$ of energy per day for cooking, how long would the cylinder last ?

(b) Assuming that 30% of the gas is wasted due to incomplete combustion, how long would the cylinder last ?

3. Assuming that 50% of the heat is useful, ow many kg of water at $15°C$ can be heated to $95°C$ by burning 200 litre of methane at STP ? The heat of combustion of methane is $211kcal/mol$. Specific heat of water is $1.0kcalkg^{-1}K^{-1}$.

4. 1.0litre sample of a mixture of CH_4 and O_2 measured at $25°C$ and $740 \rightarrow rr$, was allowed to react at constant pressure in a calorimeter, together with its contents had a heat capacity of $1260calK^{-1}$. The complete combustion of CH_4 to CO_2 and water caused a temperature rise in calorimeter of $0.667K$. Calculate mole $\%$ of CH_4 in the original mixture. Heat of combustion of CH_4 is $-210.8kcal$.

5. When $3.725g$ of KCl is dissolved in excess of water, the amount of heat absorbed is $X\ Kj$. Calculate the enthalpy of solution of KCl.

6. Calculate the enthalpy of solution of sodium chloride. The lattice energy of $NaCl$ is $+186kcalmol^{-1}$. And the solution enthalpies of cations and anions are respectively -97 and $-85kcalmol^{-1}$

7. Calculate the amount of heat released when heat of neutralization is $-57.0kJ$:

(a) $0.5mole$ of HNO_3 in aqueous solution.

(b) $200mL$ of $0.1MH_2SO_4$ is mixed with $150mL$ of $0.2MKOH$.

8. Calculate the heat of neutralization by mixing $200mL$ of $0.1MH_2SO_4$ and $200mL$ of $0.2MKOH$ if heat generated by the mixing is $2.3kJ$.

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9. When a student mixed $50mL$ of $1MHCI$ and $150mL$ of $1MNaOH$ in a coffee cup calorimeter, the temperature of the resultant solution increases from $21°C$ to $27.5°C$. Assuming that the calorimeter absorbs only a negligible quantity of heat, that the total volume of solution is $100mL$, its density $1gm - mL^{-1}$ and that its specific heat is $4.18Jg^{-1}$. calculate:

a. The heat change during mixing.

b. The enthalpy change for the reaction

$HCI(aq) + NaOH(aq) \rightarrow NaCI(aq) + H_2O(aq)$
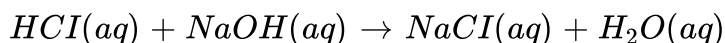
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10. Acetic acid (ethanoic acid) and hydrochloric acid react with KOH solution. The enthalpy of neutralisation of ethanoic acis is $-55.8kJmol^{-1}$ while that of hydrochloric acid is $-57.3kJmol^{-1}$. Can you think of how are these different?`

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11. The heat released on neutralisation of a strong alkali say $NaOH$ with strong acid is $13.7kcal/mol$. The heat released on neutralisation of $NaOH$ with HF if $-16.4kcal/mol$. Calculate $\Delta H°$ of ionisation of HF in water.

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12. A swimmer coming out from a pool is covered with a film of water weighing about $80g$. How much heat must be supplied to evaporate this waateer ? If latent heat of evaporation for H_2O is $40.79kJmol^{-1}$ at $100°C$.

13. How much heat is necessary to convert $100g$ ice at $0°C$ to water vapour (steam) at $100°C$? Given $\Delta H_{fusion} = 80kcal/kg$, $\Delta H_{vap} = 540kcal/kg$, heat capacity $= 1.0kcal/kg$.

14. The melting point of a certain substance is $70°C$ and its normal boiling point is $450°C$. Its enthalpy of fusion is $30.0cal/g$, enthalpy of vaporisation is $45.0cal/g$ and its heat capacity is $0.215calg^{-1}K^{-1}$. Calculate the heat required to convert $100g$ of substance from solid state at $70°C$ to vapour state at $450°C$.

**15.** Standard vaporization enthalpy of benzene at its boiling point is $30.8kJmol^{-1}$, for how long would a $100W$ electric heater have to operate in order to vaporize a $100g$ sample of benzene at its boiling temperature?

16. $0.562g$ of graphite kept in a bomb calorimeter in excess of oxygen at $298K$ and 1 atmospheric pressure was burnt according to the equation,

$$C_{Graphite} + O_{2(g)} \rightarrow CO_{2(g)}$$
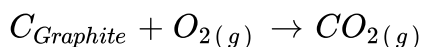
durgin the reaction, temperature rises from $298K$ o $298.89K$. If the heat capacity of the calorimeter and its contents is $20.7kJ/K$, what is the enthalpy change for the above reaction at $298K$ and $1atm$?

17. (a) Calculate the energy needed to raise the temperature of $10.0g$ of iron from $25°C$ to $500°C$ if specific heat capacity of iron if

$$0.45 J(.^\circ C)^{-1}g^{-1}$$

(b) What mass of gold (of specific heat capacity $0.13J(.^\circ C)^{-1}g^{-1}$ can be heated can be heated through the same temperature difference when supplied with the same amount of energy as in (a) ?

18. When Fe powder reacts with chlorine . $FeCl_{3(s)}$ is obtained in two steps :

$$Fe((s)) + Cl_{2(g)} \rightarrow FeCl_{2(s)}$$

$$FeCl_{2(s)} + \frac{1}{2}Cl_{2(s)} \rightarrow FeCl_{3(s)}$$
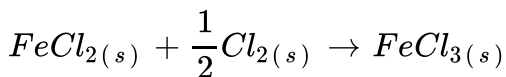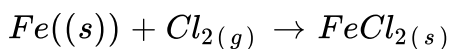
If standard enthalpy of formation $\left(\Delta H_f^\circ\right)$ of $FeCl_2$ is $-341.8kJmol^{-1}$ and heat of reaction for conversion of $FeCl_2$ into $FeCl_3$ is $-57.7kJmol^{-1}$, then calculate the enthalpy of formation of $FeCl_{3(s)}$.
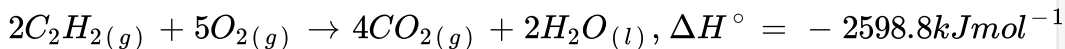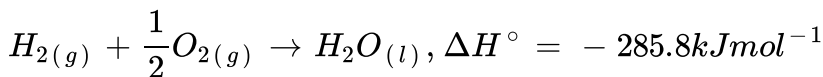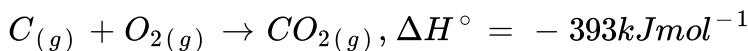
19. Calculate the standard enthalpy of combustion of CH_4, it standard enthalpies of formation of $CH_{4(g)}, H_2O_{(l)},$ and $CO_{2(g)}$ are

$-74.81 kJmol^{-1}$, $-285.83 kJmol^{-1}$ and $-393.51 kJmol^{-1}$

respectively.

20. Calculate the standard enthalpy of formation of acetylene from the following data :

$$C_{(g)} + O_{2(g)} \rightarrow CO_{2(g)}, \Delta H^\circ = -393 kJmol^{-1}$$

$$H_{2(g)} + \frac{1}{2}O_{2(g)} \rightarrow H_2O_{(l)}, \Delta H^\circ = -285.8 kJmol^{-1}$$

$$2C_2H_{2(g)} + 5O_{2(g)} \rightarrow 4CO_{2(g)} + 2H_2O_{(l)}, \Delta H^\circ = -2598.8 kJmol^{-1}$$
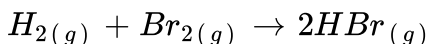
.

Hess Law

1. The heat released on neutralisation of a strong alkali say $NaOH$ with strong acid is $13.7 kcal/mol$. The heat released on neutralisation of

$NaOH$ with HF if $-16.4kcal/mol$. Calculate $\Delta H°$ of ionisation of HF in water.

2. Calculate the enthalpy change during the reaction :

$$H_{2(g)} + Br_{2(g)} \rightarrow 2HBr_{(g)}$$

Given, $\quad e_{H-H} = 435kJmol^{-1}$, $e_{Br-Br} = 192kJmol^{-1}$ $\qquad$ and $e_{H-Br} = 368kJmol^{-1}$.

3. Determine enthalpy change for the reaction,

$$CH_{4(g)} + Cl_{2(g)} \rightarrow CH_3Cl_{(g)} + HCl_{(g)}$$
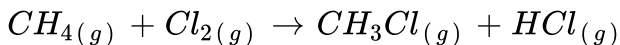
Bond energies for $C-H, C-Cl, Cl-Cl, H-Cl$ are 412, 338, 242, 431$kJmol^{-1}$ respectively.

4. The heat of atomisation of PH_3 is 228 K cal/mol and that os P_2H_4 is 335 kCal/mol. The energy of $P - P$ is (in kcal)

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Misc Problems

1. In solid NH_3 each NH_3 molecule has six other NH_3 molecules as nearest neighbouts. ΔH of sublimation of NH_3 at the melting point is $30.8 kJmol^{-1}$ and the estimated ΔH of sublimation in the absence of $H -$ bonding is $14.4 kJmol^{-1}$. What is the strength of a hydrogen bond in solid ammonia ?

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2. During one of his adventure Chacha Chaudhary got trapped in an underground cave which was sealed two hundred years back. The air inside was poisonous and contains CO in addition to O_2 and N_2. Sabu,

being huge, could not enter cave. In order to save Chacha Chaudhary he started sucking the poisonous air out of the cave by mouth. In each cycle he used to fill his lungs with cave air and exhale it out in the surroundings. In the mean time fresh air $(N_2 + O_2)$ from the surrounding effused into cave till the pressure was 1 atmosphere. Each time Sabu sucked air,the pressure in the cave dropped ito $1/2atm$. An initial sample of air taken from the cave measured $11.2mL$ at STP and give $7J$ on complete combusion at constant pressure.

(a) If the safe level of CO required in cave for life is less thatn $0.001\,\%$ by volume, how many times does Sabu need to suck out air in order to save Chacha Chaudhary ?

(b) Sabu should rescue Chacha Chaudhary within 10 minutes else he will die. Precious 80 second are wasted in thinking of a way to rescue him. At maximum how much time should each cycle of inhaling $-$ exhaling take. Given, $\Delta H_{comb}CO = -280kJmol^{-1}$? Neglect Graham's law effect during operations.
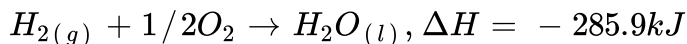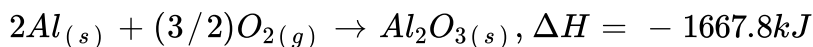
3. ΔH for combustion of ethane and ethyne are -341.1 and $-310.0 kcal$ respectively. Which gas is better for welding purpose and why ?

4. Thermochemical equation for two rocket fuels are given below :

$$2Al_{(s)} + (3/2)O_{2(g)} \rightarrow Al_2O_{3(s)}, \Delta H = -1667.8 kJ$$

$$H_{2(g)} + 1/2O_2 \rightarrow H_2O_{(l)}, \Delta H = -285.9 kJ$$

5. Specific heat of $Li(s)$, $Na(s)$, $K(s)$, $Rb(s)$ and $Cs(s)$ at $398K$ are $3.57, 1.23, 0.756, 0.363$ and $0.242 Jg^{-1}K^{-1}$ respectively. Compute the molar heat capacity of these elements and identify any periodic trend. If there is trend, use it to predict the molar heat capacity of Fr.

1. The heat liberated on complete combustion of $7.8g$ benzene is $327kJ$. This heat has been measured at constant volume and at $27°C$. Calculate heat of combustion of benzene at constant pressure at $27°C$. $\left(R = 8.3Jmol^{-1}K^{-1}\right)$

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1. When 2mole of C_2H_6 are completely burnt $-3129kJ$ of heat is liberated. Calculate the heat of formation of C_2H_6. $\Delta_f H^{\ominus}$ for CO_2 and H_2O are -395 and $-286kJ$, respectively.

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1. The heats of combustion of $C_2H_{4(g)}, C_2H_{6(g)}$ and $H_{2(g)}$ are $-1405, -1558.3$ and $-285.6kJ$ respectively. Calculate heat of hydrogenation of ethylene.

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1. At $300K$, the standard enthalpies of formation of $C_6H_5COOH_{(s)}, CO_{2(g)}$ and $H_2O_{(l)}$ are $-408, -393$ and $-286kJmol^{-1}$ respectively. Calculate the heat of combustion of benzoic acid at

(i) constant pressure,

(ii) constant volume. $(R = 8.31Jmol^{-1}K^{-1})$

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1. Calculate standard heat of formation of CS_2. Given that standard heat of combustion of C, S and CS_2 are $-393.3, -293.72$ and $-1108.76 kJmol^{-1}$.

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Exercise 7

1. The standard ethelpy of combustion at $25°C$ of hydrogen, cyclohexene (C_6H_{10}), and cyclohexane (C_6H_{12}) are $-241, -3800$, and $-3920 kJmol^{-1}$ repectively. Calculate the heat of hydrogenation of cyclohexane.
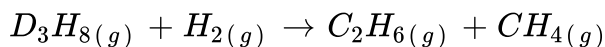
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Exercise 8

1. From the following data, calculate the enthalpy change for the combustion of cyclopropane at $298K$. The enthalpy of formation of $CO_{2(g)}$, $H_2O_{(l)}$ and $Propene_{(g)}$ are -393, -285.8 and $20.42kJmol^{-1}$ respectively. The enthalpy of isomerisation of cyclopropane to propene is $-33.0kJmol^{-1}$

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Exercise 9

1. Determine enthalpy change for,

$$D_3H_{8(g)} + H_{2(g)} \rightarrow C_2H_{6(g)} + CH_{4(g)}$$

at $25°C$ using heat of combustion values under standard condition.

$Compounds$	$H_{2(g)}$	$CH_{4(g)}$	$C_2H_{6(g)}$	$C_{(Graphite)}$
$\Delta H° in kJ/mol$	-285.8	-890.0	-1560.0	-393.5

The standard heat of formation of $C_3H_{8(g)}$ is $-103.8kJmol^{-1}$.

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Exercise 10

1. The molar heat of formation of $NH_4NO_{3(s)}$ is $-367.54kJ$ and those of $N_2O_{(g)}$, $H_2O_{(l)}$ are 81.46 and $-285.8kJ$ respectively at $25°C$ and 1 atmosphere pressure. Calculate ΔH and ΔU of the reaction $NH_4NO_{3(s)} \rightarrow N_2O_{(g)} + 2H_2O_{(l)}$.

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Exercise 11

1. Standard heat of formation of CH_4, CO_2 and $H_2O_{(g)}$ are -76.2, -394.8 and $-241.6 kJmol^{-1}$ respectively. Calculate the amount of heat evolved by burning $1m^3$ of CH_4 measured under normal conditions.

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Exercise 12

1. Determine the value of ΔH and ΔU for the reversible isothermal evaporation of $90.0g$ of water at $100^\circ C$. Assume that water behaves as an ideal gas and heat of evaporation of water is $540 calg^{-1} \left(R = 2.0 calmol^{-1}K^{-1} \right)$.
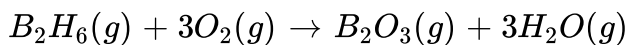
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Exercise 13

1. The standard molar enthalpies of formation of cyclohexane (l) and benzene (l) at $25^\circ C$ are -156 and $+49 kJmol^{-1}$, respectively. The standard enthaly of hydrogenation of cyclohenxene (l) at $25^\circ C$ is $-119 kJmol^{-1}$ Use this data to estimate the magnitude of the resonance enegry of benzene.

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1. Diborane is a potential rocket fuel that undergoes combustion according to the reaction,

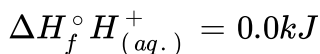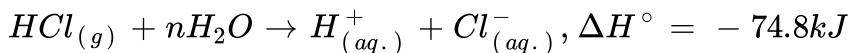$$B_2H_6(g) + 3O_2(g) \rightarrow B_2O_3(g) + 3H_2O(g)$$

From the following data, calculate the enthalpy change for the combustion of diborane:

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1. Calculate ΔH_f° for chloride ion from the following data :

$$\frac{1}{2}H_{2(g)} + \frac{1}{2}Cl_{2(g)} \rightarrow HCl_{(g)}, \Delta H_f^\circ = -92.4kJ$$

$$HCl_{(g)} + nH_2O \rightarrow H_{(aq.)}^+ + Cl_{(aq.)}^-, \Delta H^\circ = -74.8kJ$$

$$\Delta H_f^\circ H_{(aq.)}^+ = 0.0kJ$$

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Exercise 16

1. The enthalpy change involved in the oxidation of glucose is $-2880 kJmol^{-1}$. Twenty five per cent of this energy is available for muscular work . If $100 kJ$ of muscular work is needed to walk one kilometre, what is the maximum distance that a person will be able to walk after eating $120 g$ of glucose ?

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Exercise 17

1. A gas mixture of $3.67 L$ of ethylene and methane on complete combustion at $25°C$ produces $6.11 L$ of CO_2. Find out the heat evolved on buring $1 L$ of the gas mixture. The heats of combustion of ethylene and methane are -1423 and $-891 kJmol^{-1}$, respectively, at $25°C$.

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1. An intimate mixture of ferric oxide and aluminium is used as solid fuel in rockets. Calculate the fuel value per cm^3 of the mixture.

Heats of formation and densities are as follows:

$H_{f(Al_2O_3)}^{\ominus} = -399 kcal mol^{-1}$, $H_{f(Fe_2O_3)}^{\ominus} = -199 kcal mol^{-1}$

Density of $Fe_2O_3 = 4.0 gcm^{-3}$, Density of $Al = 2.0 gcm^{-3}$
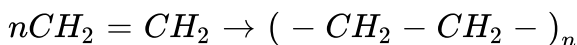
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1. The bond dissociation energy of gaseous H_2, Cl_2 and HCl are 104, 58 and $103 kcal mol^{-1}$ respecitvely. Calculate the enthalpy of formation for HCl gas.

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1. The polymerisation of ethylene to linear polyethylene is represented by the reaction

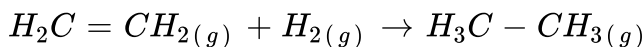$$nCH_2 = CH_2 \rightarrow (- CH_2 - CH_2 -)_n$$

When n has a large integral value. Given theat the average enthalpies of bond dissociation for $C = C$ and $C - C$ at $298K$ are $+590$ and $+331 kJmol^{-1}$ respectively, calculate the enthalpy of polymerisation per mole of ethylene at $298K$.

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1. Calculate enthalpy change of the following reaction :

$$H_2C = CH_{2(g)} + H_{2(g)} \rightarrow H_3C - CH_{3(g)}$$
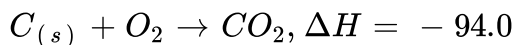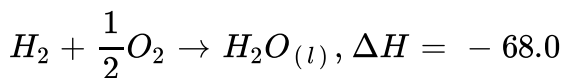
The bond energy of $C - H, C - C, C = C, H - H$ are $414, 347, 615$ and $435 kJmol^{-1}$ respectively.

Exercise 22

1. Using the data (all vaues in $kcal\,mol^{-1}\,at\,25°\,C$) given below, calculate bond energy of $C - C$ and $C - H$ bonds.

$C_{(s)} \rightarrow C_{(g)}, \Delta H = 172$

$H_2 \rightarrow 2H, \Delta H = 104$

$H_2 + \dfrac{1}{2}O_2 \rightarrow H_2O_{(l)}, \Delta H = \ -68.0$

$C_{(s)} + O_2 \rightarrow CO_2, \Delta H = \ -94.0$
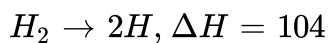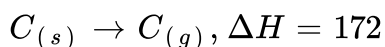
Heat of combustion of $C_{20}H_6 = \ -372.0$

Heat of combustion of $C_3H_8 = \ -530.0$

Exercise 23

1. Calculate the resonance enegry of N_2O form the following data

$\Delta_f H^{\ominus} of N_2O = 82 kJmol^{-1}$

Bond enegry of $N \equiv N$, $N = N$, $O = O$, and $N = O$ bond is

946, 418, 498, and $607 kJmol^{-1}$, respectively.

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Exercise 24

1. Compute the heat of formation of liquie methyl alcohol is kilojoule per mol using the following data. Heat of vaporisation of liquid methyl alcohol $= 38 kJ/mol$. Heat of formation of gaseous atoms from the elements in their standard states

$: H = 218 kJ/mol$, $C = 715 kJ/mol$, $O = 249 kJ/mol$.

Average bond energies :

$C - H 415 kJ/mol$, $C - O 356 kJ/mol$, $O - H 463 kJ/mol$.

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1. In order to get maximum calorific output,a burner should have an optimum fuel to oxygen ratio which corresponds to 3 times as much oxygen as is required theoretically for complete combustion of the fuel. A burner which has been adjusted for methane as fuel (with X litre / hour OF CH_4 and $6X$ litre / hour of O_2) is to be readjusted for butane C_4H_{10}. In order to get same calorific output, what should be the rate of supply of butane and oxygen ? Assume that losses due to incomplete combustion etc., are the same for both fuels and that gases behave ideally. Heat of combustion $CH_4 = 809kJmol^{-1}$, $C_4H_{10} = 2878kJmol^{-1}$

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1. The standard heat of formation values of $SF_6(g)$, $S(g)$, and $F(g)$ are -1100, 275, and $80 kJmol^{-1}$, respectively. Then the average $S - F$ bond enegry in SF_6

Exercise 27

1. For the reaction

$$2CO + O_2 \rightarrow 2CO_2, \Delta H = -560 kJ,$$
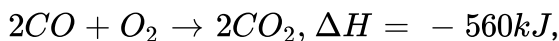
$2mol$ of CO and $1mol$ of O_2 are taken in a container of volume $1L$. They completely form $2mol$ of CO_2. The gaseous deviate appreciably from ideal behaviour. If the pressure in the vessel changes from 70 to $40atm$, find the magnetic (absolute) value of $\Delta U at 500K$. $(1L - atm = 0.1kJ)$

Exercise 3 A Objective Problems

1. Equal volumes of $1M HCI$ and $1M H_2SO_4$ are neutralised by $1M NaOH$ solution and x and $ykJ/$ equivalent of heat are liberated, respectively. Which of the following relations is correct?

A. $x = y$

B. $x = \dfrac{y}{2}$

C. $x = 2y$

D. None of these

Answer: B

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2. The standard heat of combustion of solid boron is equal to :

A. $\Delta_f H^\circ (B_2O_3)$

B. $\dfrac{1}{2}\Delta_f H^\circ (B_2O_3)$

C. $2\Delta_f H^\circ (B_2O_3)$

D. $-\dfrac{1}{2}\Delta_f H^\circ (B_2 O_3)$

Answer: B

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3. The compound with negative value of heat of formation are called :

    A. endothermic compound

    B. exothermic compound

    C. hear of formation compounr

    D. None of these

Answer: B

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4. Which reaction is endothermic in nature ?

A. $CaCO_3 \rightarrow CaO + CO_2$

B. $C + 1/2 O_2 \rightarrow CO$

C. $NaOH + HCl \rightarrow NaCl + H_2O$

D. $CH_4 + 2O_2 \rightarrow CO_2 + 2H_2O$
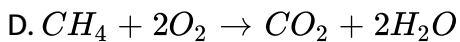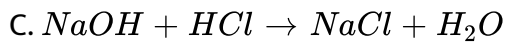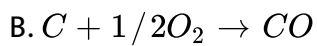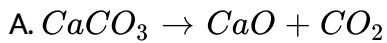
Answer: A

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5. Which plot represents for an exothermic reaction ?

A.

B.

(c) C.

(d) D.
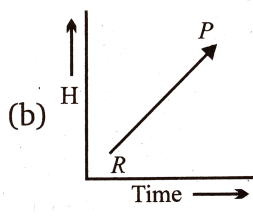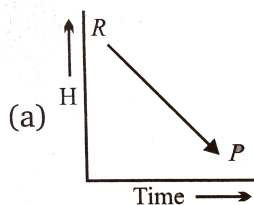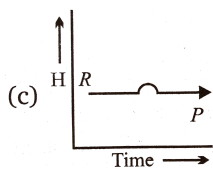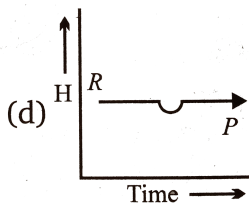
Answer: A

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6. For the reaction , $3O_2 \rightarrow 2O_3$, $\Delta H = +ve$. We can say that :

A. ozone is more stable than oxygen

B. ozone is less stable than oxygen and ozone decomposes forming

   oxygen readily

C. oxygen is less stble than ozone and oxygen readily forms ozone

D. None of these

Answer: B

---

7. The enthalpy changes of formation of the gaseous oxides of nitrogen $(N_2O$ and $NO)$ are positive because of :

    A. the high bond energy of the nitrogen molecule

    B. the hight electrone affinity of oxygen atoms

    C. the high electron affinity of nitrogen atoms

    D. the tendency of oxygen to form O^{2-}

Answer: A

---

8. The heats of neutralisation of four acids A, B, C and D are

$-13.7, -9.4, -11.2$ and $-12.4 kcal$ respectively, when they are

neturalised by a common base. The acidic character obeys the order :

A. $A > B > C > D$

B. $A > D > C > B$

C. $D > C > B > A$

D. $D > B > C > A$

Answer: B

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9. Which fuel provides the highest calorific values ?

A. Charcoal

B. Kerosene

C. Wood

D. Dung

Answer: B

10. In a flask, colourless N_2O_4 is in equilibrium with brown-coloured NO_2. At equilibrium, when the flask is heated to $100°C$ the brown colour deepens and on cooling, the brown colour became less coloured. The change in enthalpy ΔH for the ayatem is

    A. negative

    B. positive

    C. zero

    D. undefined

Answer: B

11. The difference between the heats of reaction at constant pressure and a constant volume for the reaction

$2C_6H_6(l) + 15O_2(g) \rightarrow 12CO_2(g) + 6H_2O(l)$ at $25°C$ in kJ is

A. -7.43

B. $+3.72$

C. -3.72

D. $+7.43$

Answer: A

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12. The temperature of a $5mL$ of strong acid increases by $5°$ when$5mL$ of strong base is added to it . If $10mL$ of each are mixed, temperature should increase by :

A. $5°C$

B. $10°C$

C. $15°C$

D. cannot be know

Answer: A

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13. Heat of combustion of CH_4, C_2H_4, C_2H_6 are $-890, -1411$ and $-1560 kJ/mol$ respectively. Which has the lowest calorific fuel value ?

A. CH_4

B. C_2H_4

C. C_2H_6

D. Same for all

Answer: B

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14. In which case of mixing of a strong acid and a base each of $1N$ concentration, temperature increase is highest ?

A. $15mL$ acid $-20mL$ alkali

B. $10mL$ acid $-40mL$ alkali

C. $25mL$ acid $-25mL$ alkali

D. $35mL$ acid $-15mL$ alkali

Answer: C

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15. The dissociation energy of CH_4 and C_2H_6 are respectively 360 and $620kcal/mol.$ The bond energy of $C-C$ bond is :

A. $260kcal/mol$

B. $180kcal/mol$

C. $130kcal/mol$

D. $80kcal/mol$

Answer: D

---

16. Given that ,

$$A(s) \rightarrow A(l)\Delta H = x$$

$$A(l) \rightarrow A(g), \Delta H = y$$
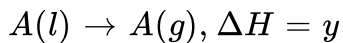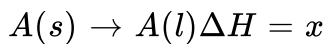
The heat of sublimation of A will be :

A. $x - y$

B. $x + y$

C. x or y

D. $-(x + y)$

Answer: B

17. A person requires $2870 kcal$ of energy to lead normal daily life. If heat of combustion of cane sugar is $-1349 kcal$, then his daily comsumption of sugar is :

A. $728g$

B. $0.728g$

C. $342g$

D. $0.342g$

Answer: A

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18. If, combustion of $4g$ of CH_4 liberates $2.5 kcal$ of heat, the heat of combustion of CH_4 is :

A. $-20 kcal$

B. $-10 kcal$

C. $2.5kcal$

D. $-5kcal$

Answer: B

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19. A solution of $500mL$ of $2MKOH$ is added to $500mL$ of $2MHCl$ and the mixture is well shaken. The rise in temperature T_1 is noted. The experiment is then repeated using $250mL$ of each solution and rise in temperature T_2 is againg noted. Assume all heat is taken up by the solution :

A. $T_1 = T_2$

B. T_1 is 2 times as larger as T_2

C. T_2 is twice larger as T_1

D. T_1 is 4 time as larger as T_2

Answer: A

20. Under the same conditions, how many mL of $1MKOH$ and $0.5MH_2SO_4$ solutions, respectively, when mixed to form a total volume of $100mL$, produces the highest rise in temperature?

A. $67:33$

B. $33:67$

C. $40:60$

D. 50:50`

Answer: D

21. AB, A_2 and B_2 are diatomic molecules. If the bond enthalpies of A_2, AB and B_2 are in the ratio $1:1:0.5$ and the enthalpy of formation of

AB from A_2 and B_2 is $-100kJmol^{-1}$, what is the bond enthalpy of A_2 ?

A. $400kJmol^{-1}$

B. $200kJmol^{-1}$

C. $100kJmol^{-1}$

D. $300kJmol^{-1}$

Answer: A

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22. ΔC_p for change , $N_{2(g)} + 3H_{2(g)} = 2NH_{3(g)}$ is :

A. $C_{pNH_3} - (C_{pN_2})$

B. $2C_{pNH_3} - (C_{pN_2} + 3C_{pH_2})$

C. $2C_{pNH_3} - (C_{pH_2})$

D. $2C_{pNH_3} + (C_{pN_2} + 3C_{pH_2})$

Answer: B

23. Consider the reactions :

$$C_{(s)} + 2H_{2(g)} \rightarrow CH_{4(g)}, \Delta H = -Xkcal$$

$$C_{(g)} + 4H_{(g)} \rightarrow CH_{4(g)}, \Delta H - X_1 kcal$$

$$CH_{4(g)} \rightarrow CH_{3(g)} + H_{(g)}, \Delta H = +Ykcal$$
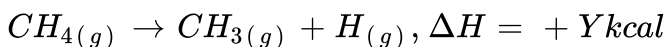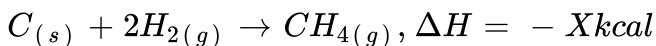
The average bond energy of $C - H$ bond is :

A. $\dfrac{X}{4} kcalmol^{-1}$

B. $Y kcalmol^{-1}$

C. $\dfrac{X_1}{4} kcalmol^{-1}$

D. $X_1 kcalmol^{-1}$

Answer: C

24. Which of the following is incorrect about the reaction :

$$C + O_{2(g)} \rightarrow CO_{2(g)}, \Delta H = -94.3kcal \text{ at } 25°C \text{ and } 1atm ?$$
$$(Diamond)$$
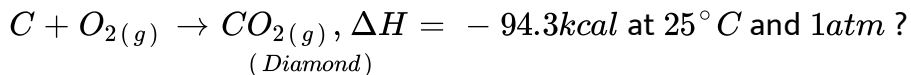
A. Heat of combustion of $C = -94.3kcal$

B. Heat of formation of $CO_2 = -94.3kcal$

C. $\Delta H = \Delta U$

D. Standard heat of formation of $CO_2 = -94.3kcal$

Answer: D

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25. For $N_2(g) + 3H_2(g) \rightarrow 2NH_3(g) + 22kcal$, E_a for the reaction is $70kcal$. Hence, the activation energy for $2NH_3(g) \rightarrow N_2(g) + 3H_2(g)$ is :

A. $70kcal$

B. $92kcal$

C. $48kcal$

D. None of these

Answer: B

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26. Bond energy of $N - H, H - H$ and $N \equiv N$ are a, b, c respectively.

The ΔH for the reaction,

$2NH_3 \rightarrow N_2 + 3H_2$ is :
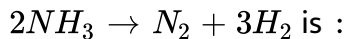
A. $6a - 3b - c$

B. $6a + 3b + c$

C. $a + 6b - c$

D. $6a + b - 3c$

Answer: A

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27. If heat of neutralisation is $-13.7kcal$ at $25°C$ and $H^\circ_{f(H_2O)} = -68kcal$, then standard enthalpy of OH^- would be :

A. $54.3kcal$

B. $-54.3kcal$

C. $71.3kcal$

D. $-71.3kcal$

Answer: B

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28. If $\frac{1}{2}X_2O_{(s)} \rightarrow X_{(s)} + \frac{1}{4}O_{2(g)}, \Delta H = 90kJ$ then heat change during reaction of metal X with $1moleO_2$ to form oxide to maximum extent is :

A. $-360kJ$

B. $-180kJ$

C. $+360kJ$

D. $+180kJ$

Answer: A

29. The data given below are for vapour phase reactions at constant pressure.

$C_2H_6 \rightarrow \dot{C_2}\dot{H_5} + \dot{H}, \Delta H = -4200kJmol^{-1}$

$\dot{C_2}H_6 \rightarrow C_2H_4 + \dot{H}, \Delta H = 168kJmol^{-1}$

The enthalpy change for the reaction ,

$2\dot{C_2}H_5 \rightarrow C_2H_6 + C_2H_4$ is :
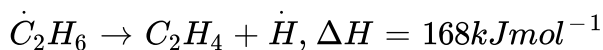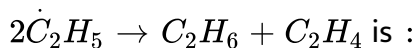
A. $+250kJmol^{-1}$

B. $+588kJmol^{-1}$

C. $-252kJmol^{-1}$

D. $-588kJmol^{-1}$

Answer: C

---

30. The product of combustion of an aliphatic thiol (RSH) at $298K$ are :

    A. $CO_{2(g)}$, $H_2O_{(g)}$ and $SO_{2(g)}$

    B. $CO_{2(g)}$, $H_2O_{(l)}$ and $SO_{2(g)}$

    C. $CO_{2(l)}$, $H_2O_{(l)}$ and $SO_{2(g)}$

    D. $CO_{2(g)}$, $H_2O_{(l)}$ and $SO_{2(l)}$

Answer: B

---

31. The bond energy of H_2 is $104.3 kcal mol^{-1}$. If means that :

A. $104.3 kcal$ heat is needed to break up $'N'$ bonds in N molecules of

H_2.

B. $104.3 kcal$ heat is needed to break up 6.023×10^{23} molecules into

1.2046×10^{24} atoms of H

C. $104.3 kcal$ heat is evolved during combination of $2N$ atoms of H to

form N molecules of H_2.

D. all of these

Answer: D

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32. Heat of neutralisation of $NaOH$ and HCl is $-57.46 kJ/$ equivalent.

The heat of ionisation of water in kJ/mol is :

A. -57.46

B. $+57.46$

C. -114.92

D. $+114.92$

Answer: B

33. The lattice energy of solid $NaCI$ is $180 kcal mol^{-1}$. The dissolution of the solid in H_2O is endothermic to the extent of $1.0 kcal mol^{-1}$. If the hydration energies of $Na^{\oplus}$ and $CI^{\ominus}$ ions are in the ratio of $6:5$ what is the enthalpy of hydration of sodium ion?

A. $-85.6 kcal mol^{-1}$

B. $-97.64 kcal mol^{-1}$

C. $+82.6 kcal mol^{-1}$

D. $+100 kcal mol^{-1}$

Answer: B

34. Heat of neutralisation of HF is :

A. $57.32kJ$

B. $> 57.32kJ$

C. $< 57.32kJ$

D. none of these

Answer: B

35. The heat of atomisation of $PH_{3(g)}$ is $228kcalmol^{-1}$ and that of P_2H_4 is $355kcalmol^{-1}$. Calculate the average bond energy of $P - P$ bond.

A. 102

B. 51

C. 26

D. 204

Answer: B

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36. Given that :

$$2CO_{(g)} + O_{2(g)} \rightarrow 2CO_{2(g)}, \Delta H^\circ = -PkJ$$

$$C_{(s)} + O_{2(g)} \rightarrow CO_{2(g)}, \Delta H^\circ = -QkJ$$
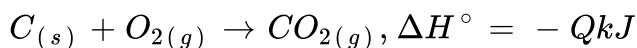
the enthalpy of formation of carbon monoxide is :

A. $\dfrac{P - Q}{2}$

B. $2Q - P$

C. $P - 2Q$

D. $\dfrac{P - 2Q}{2}$

Answer: D

---

37. For which reaction $\Delta H = \Delta U$?

A. $PCl_{5(g)} \rightarrow PCl_{3(g)} + Cl_{2(g)}$

B. $2CO_{(g)} + O_{2(g)} \rightarrow 2CO_{2(g)}$

C. $H_{2(g)} + Br_{2(g)} \rightarrow 2HBr_{(g)}$

D. $C_{(s)} + 2H_2O_{(g)} \rightarrow 2H_{2(g)} + CO_{2(g)}$

Answer: C

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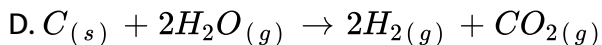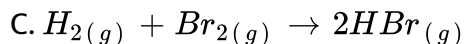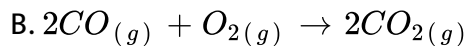
38. The enthalpy of hydrogenation of cyclohexene is $-119.5 kJmol^{-1}$. If resonance energy of benzene is $-150.4 kJmol^{-1}$, its enthalpy of hydrogenation would be :

A. $-269.9 kJmol^{-1}$

B. $-358.5 kJmol^{-1}$

C. $-508.9 kJmol^{-1}$

D. $-208.1 kJmol^{-1}$

Answer: D

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39. For which of the following reactions heat of formation $(\Delta_f H)$ is equal to $\Delta H/2$?

A. $N_2 + O_2 \rightarrow 2NO, \Delta H = X_1$

B. $CO + O_2 \rightarrow CO_2, \Delta H = X_2$

C. $PCl_3 + Cl_2 \rightarrow PCl_5, \Delta H = X_3$

D. $C + O_2 \rightarrow CO_2, \Delta H = X_4$
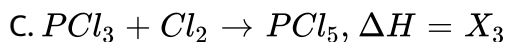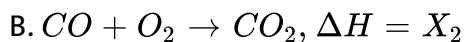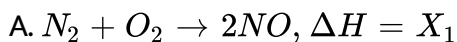
Answer: A

40. For a hypothetical reaction ,$3A \rightarrow A_3$

$$\Delta C_p (inJ) = 6.0 + 2.0 \times 10^{-3}T$$

$$\Delta H = -20kJmol^{-1} \text{ at } 300K$$

The temperature at which reaction neither absorbs nor releases heat is :

A. $2557° C$

B. $255° C$

C. $2284° C$

D. $228° C$

Answer: C

41. In a flask, colourless N_2O_4 is in equilibrium with brown-coloured NO_2.

At equilibrium, when the flask is heated to $100°C$ the brown colour

deepens and on cooling, the brown colour became less coloured. The change in enthalpy ΔH for the ayatem is

A. (a) The ΔH for the reaction :

$N_2O_{4(g)} \Leftrightarrow 2NO_{2(g)}$ is $+ve$
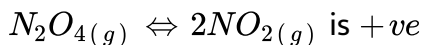
B. Paramagnetic decreases on cooling

C. The $\Delta H - \Delta U$ at $100°C$ is equal to $200cal$

D. Dimerisation is reduced on heating

Answer: C

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42. $1mole$ of ice melts at $0°C$ and constant pressure of $1atm$ by absorbing $1.44kcal$ heat . The density of ice $0.918g/Ml$ and of water $1g/mL$ respectively. The two values of ΔH and ΔU differ by :

A. $-0.039cal$

B. $+0.039cal$

C. $- 0.39 cal$

D. $+0.39 cal$

Answer: A

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43. Which of the following statement is wrong for

$C_{(graphite)} \rightarrow C_{(diamond)} ? \Delta H^{\circ} = + 1.90 kJ$
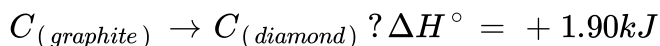
A. $\Delta H^{\circ} - (f)$ for$C_{(graphite)}$ is zero

B. $\Delta H^{\circ} - (f)$ for$C_{(diamond)}$ is $+1.90 kJ$

C. The enthalpy of formation of element in a form other than its most

stable one is non zero

D. None of these

Answer: D

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44. $2 moles$ of CO and $1 mole$ of O_2 are allowed to react completely to form CO_2 at $27°C$. If the heat liberated during the course of reaction $2CO + O_2 \rightarrow 2CO_2$ at constant pressure is $560kJ$, the amount of heat liberated by carrying the reaction in one litre vessel will be :(Given $1 litre - atm = 0.1kJ$)

A. $+535.37kJ$

B. $-557.537kJ$

C. $-58kJ$

D. $+57kJ$

Answer: B

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45. One mole of a gas is allowed to expand freely in vacuum at $27°C$. The work done during the process is :

A. zero

B. $300kJ$

C. $150kJ$

D. $300J$

Answer: A

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46. A system is provided $50 \times 10^3 J$ energy and work done on the system is $100J.$ The change in internal energy is :

A. $50kJ$

B. $50.1kJ$

C. $150J$

D. $50J$

Answer: B

47. A piston exering a pressure of one atm rests on the surface of water at $373K$. The pressure is reduced to smaller extent and as a result $10gm$ of water evaporates and absorbs $22.4kJ$ of heat. The change in internal energy is :

   A. $19.678kJ$

   B. $22.06kJ$

   C. $23.943kJ$

   D. $20.678kJ$

Answer: D

48. For a reaction $\Delta C_p = 2.0 + 0.2T cal°C$ and enthalpy of reaction at $10K$ is $-14.3kcal$. The enthalpy of this reaction at $100K$ is :

A. $-16.3kcal$

B. $-17.02kcal$

C. $-13.13kcal$

D. $-14.08kcal$

Answer: C

49. The latent heat of vaporisation of liquid is $10kcalmol^{-1}$ at $1atm$ and $227°C$. What will be the change in internal energy of $3moles$ of the liquid at same condition ?

A. $14kcal$

B. $-14kcal$

C. $27kcal$

D. $-27kcal$

Answer: C

50. One gram sample of NH_4NO_3 is decomposed in a bomb calorimeter. The temperature of the calorimeter increases by $6.23K$. The heat capacity of the system is $1.23kJ/g - deg$. The molar heat of decomposition for NH_4NO_3 is :

A. $- 16.1 kJmol^{-1}$

B. $- 7.53 kJmol^{-1}$

C. $- 621.89 kJmol^{-1}$

D. $- 498.1 kJmol^{-1}$

Answer: C

51. Bond dissociation enthalpy of H_2, Cl_2 and HCl are $434, 242$ and $431 kJmol^{-1}$ respectively. Enthalpy of formation of HCl is :

A. $-93 kJmol^{-1}$

B. $245 kJmol^{-1}$

C. $93 kJmol^{-1}$

D. $-245 kJmol^{-1}$

Answer: A

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52. The amount of heat released during the reaction of $300 mL$ of $1MHCl$ with 100mLof1M NaOH$is:`

A. $573 kJ$

B. $573 \times 10^{-3} Kj$

C. $57.3 kJ$

D. $5.73kJ$

Answer: D

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53. The change is entropy when $1mole$ of an ideal gas is compressed to $1/4th$ to its intial volume and simultaneously heated to twice of its initial temperature is :

A. $[C_v - R]\ln 2$

B. $[C_v - 2R]\ln 2$

C. $[C_v + 2R]\ln 2$

D. $[C_v - R]\ln 4$

Answer: B

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1. Which of the following pairs are correctly matched ?

   A. Arrhenius equation : Variation of enthalpy of a reaction with temperature.

   B. Kirchhoff equation : Variation of rate constant with temperature

   C. Second law of thermodynamics : Entropy of an isolated system tends to increase and reach a maximum value

   D. Hess's law of constant heat summation : Enthalpy change in a reaction is always constant and independent of the manner in which he reactions occurs

Answer: C::D

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2. Which of the following statements is (are) correct ?

A. The heat of neutralization of a strong acid with a strong base is

   always the same

B. The enthalpy of combustion is alwaysa negative

C. A spontaneous change involves a lowering of free energy

D. The enthalpy of an element in the standard state is assumed to be

   unity at $298K$

Answer: A::B::C

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3. Which is (are) correct for ideal gas ?

A. $\left(\dfrac{\delta U}{\delta T}\right)_P = 0$

B. $\left(\dfrac{\delta T}{\delta P}\right)_H = 0$

C. $\left(\dfrac{\delta E}{\delta V}\right)_T = 0$

D. $\left(\dfrac{\delta U}{\delta P}\right)_T = 0$

Answer: B::C::D

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4. Which of the following are applicable for a thermochemical equation ?

It tells :

A. about the physical state of reactants and products

B. about the allotropic form (if any) of the reactants

C. whether the reaction is exothermic or endothermic

D. whether a particular reaction is spontaneous or not

Answer: A::B::C

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5. The heat of reaction depends upon :

A. the manner by which the reaction is carried out

B. temperature at which the reaction is carried out

C. physical state of reactant and products

D. whether the reaction is carried out at constant pressure or at constant volume

Answer: B::C::D

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6. The enthalpy of formation of $UF(g)$ is $22 kcalmol^{-1}$ and that of $U(g)$ is $128 kcalmol^{-1}$.

The bond energy of the $F - F$ bond is $37 kcalmol^{-1}$. The bond dissociation energy of $UF(g)$ is (are):

A. $124.5 kcalmol^{-1}$

B. $131.1 kcalmol^{-1}$

C. $521 kJmol^{-1}$

D. $623 kJmol^{-1}$

Answer: A::C

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7. The standard heat of formation of a compound is the :

  A. change in enthalpy for the production of 1 mole of the compound

    at STP

  B. change in enthalpy for the formation of 1 mole of the compound

    from its elements

  C. change in enthalpy for the formation of 1 mole of the compound

    from its elements at $298K$ and $1atm$ pressure

D. change in enthalpy for the formation of 1 mole of the compound from its elements at $25°C$ and $760mm$ of Hg pressure.

Answer: C::D

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8. The heat of neutralization of a strong acid by a strong base is a constant because :

A. the strong acid and strong base react completely

B. the strong acid and strong base dissociate completely and only H^+ and OH^- ions react in every case

C. the salt formed do not hydrolyse

D. there is no side reaction during neutralization

Answer: B::D

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9. Which of the following is (are) true ?

A. The evaporation of water is an endothermic change

B. The conversion of white phosphours to red phosphorus is an

exothermix reaction

C. The heat of neutralization of a strong acid with a strong base is

always the same

D. ΔH is negative for endothermic reactions

Answer: A::B::C

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10. The standard heat of formation of U_3O_8 is $-853.5kcalmol^{-1}$ and

standar heat of the reaction, $3UO_2 + O_2 \rightarrow U_3O_8$ is $-76.01kcal$. The

standard heat of formation of UO_2 is (are):

A. $- 1083 kJmol^{-1}$

B. $- 1102 kJmol^{-1}$

C. $- 259 kcalmol^{-1}$

D. $302 kcalmol^{-1}$

Answer: A::C

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11. For which of the following substances is the heat of formation in the standard state zero ?

A. Aluminium

B. $C_{diamond}$

C. Zinc

D. $C_{graphite}$

Answer: A::C::D

12. Which of the following statements is (are) true ?

   A. ΔH is $-ve$ for exothermic reactions

   B. ΔH is $+ve$ for endothermic reactions

   C. The heat of neutralization of strong acid and strong bases is constant

   D. The enthalpy of fusion is $+ve$

Answer: A::B::C::D

13. The heat of combustion of ethanol was determined in a bomb calorimeter and was found to be $-670.48 kcal mol^{-1}$ at $25°C$. What will be ΔU for the same reaction at $298K$?

A. $- 2802.6 kJ$

B. $- 669.28 cal$

C. $- 670.48 kcal$

D. $- 280.26 \times 10^4 kJ$

Answer: C::D

14. If $\Delta_f H^\circ {}_- (C_3 H_8(g)) = - 85 kJ moll^{-1}$,

$\Delta_f H^\circ {}_- (C_3 H_8(g)) = - 104 kJ mol^{-1}$,

ΔH for $C_{(s)} \rightarrow C_{(g)}$ is $718 kJ mol^{-1}$ and heat of formation of $H -$ atom is $218 kJ mol^{-1}$, then :

A. $e_{C-H} = 414 kJ$

B. $e_{C-C} = 345 kJ$

C. $e_{H-H} = 218 kJ$

D. $e_{H-H} = 436 kJ$

Answer: A::B::D

15. During the melting of an ice slab at $273K$ at atmospheric pressure :

   A. Positive work is doen on the ice — water system by the atmosphere.

   B. Positive work is done by the ice — water system on the atmosphere

   C. The internal energy of the ice — water system decreases

   D. The internal energy of the ice — water system increases.

Answer: A::D

16. Select the incorrect statement (s) :

A. ΔG is $+ve$, the process is endoergic

B. ΔG is $-ve$, the process is exoergic.

C. ΔG is $-ve$, the process is non $-$ spontaneous.

D. ΔG is $-ve$, the process is spontaneous.

Answer: A::B::C

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17. A reaction in equilibrium shows the following characteristics l_k :

A. dynamic equilibrium

B. a balance between maximum and minimum enthalpies

C. $\Delta_r H$ remains constant till the equilibrium exist

D. $\Delta_r H$ changes if the temperature raised

Answer: A::B::C::D

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18. C_v and C_p denote the molar specific heat capacities of a gas at constant volume and constant pressure, respectively. Then

A. $C_p + C_v$ is larger for a diatomic ideal gas than for a monoatomic ideal gas.

B. $C_p - C_v$ is larger for a diatomic ideal gas ghtan for a monoatomic ideal gas.

C. $C_p . C_v$ is larger for a diatomic ideal gas than for monoatomic ideal gas.

D. C_p / C_{v0} is larger for a diatomic ideal gas than for a monoatomic ideal gas.

Answer: A::C

1. For the reaction,

$$C + O_2 \rightarrow CO_2, \Delta H = -393J$$

$$2Zn + O_2 \rightarrow 2ZnO, \Delta H = -412J$$
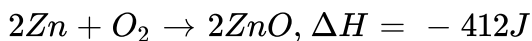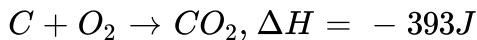
Which one is correct ?

    A. Carbon can reduce ZnO to Zn

    B. Oxidation of carbon is not feasible

    C. Oxidation of Zn is not feasible

    D. Zn liberates more heat than carbon during oxidation

Answer: A

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2. The heat requried to raise the temperature of body by $1° C$ is called :

    A. specific heat

B. thermal capacity

C. water equivalent

D. None of these

Answer: C

3. The enthalpy of reaction does not depend upon:

A. the nature of intermediate state

B. the differences in initial and final temperature

C. the physical state of reactants and product

D. use of different reactant for same product

Answer: A

4. Calculate enthalpy change of the following reaction :

$$H_2C = CH_2{}_{(g)} + H_2{}_{(g)} \rightarrow H_3C - CH_3{}_{(g)}$$
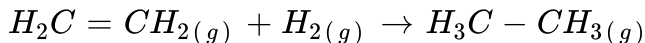
The bond energy of $C - H, C - C, C = C, H - H$ are $414, 347, 615$ and $435 kJmol^{-1}$ respectively.

A. $+125kJ$

B. $-125kJ$

C. $+250kJ$

D. $-250kJ$

Answer: B

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5. The enthalpies of combustion of carbon and carbond monoxide are -393.5 and $-283kJmol^{-1}$ respectively . The enthalpy of formation of carbond monoxide per mole is :

A. $-110.5kJ$

B. $676.5kJ$

C. $-676.5kJ$

D. $110.5kJ$

Answer: A

6. Consider the reaction,

$N_2 + 3H_2 \Leftrightarrow 2NH_3$ carried out at constant pressure and temperature. If ΔH and ΔU are change in enthalpy and change in internal energy respectively, then :

A. $\Delta H = 0$

B. $\Delta H = \Delta U$

C. $\Delta H < \Delta U$

D. $\Delta H > \Delta U$

Answer: C

7. If the bond dissociation energies of XY, X_2 and Y_2(all diatomic molecules) are in the ratio $1:1:0.5$ and $\Delta_f H$ of XY is $-200kJmol^{-1}$. The bond dissociation energy of X_2 will be :

A. $800kJmol^{-1}$

B. $200kJmol^{-1}$

C. $300kJmol^{-1}$

D. $400kJmol^{-1}$

Answer: A

8. The standard enthalpy of formation $(\Delta_f H^\circ)$ at $298K$ for methane $(CH_{4(g)})$ is $-74.8 kJmol^{-1}$. The additional information required to determine the average energy for $C - H$ bond formation would be :

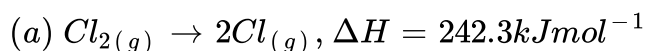A. the dissociation energy of H_2 and enthalpy of sublimation of carbon

B. latent heat of vaporisation of methane

C. the first four ionisation energy of carbon and electrone gain enthalpy of hydrogen

D. the dissociation energy of H_2 molecule

Answer: A

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9. The enthalpy change for the following process are listed below:

(a) $Cl_{2(g)} \rightarrow 2Cl_{(g)}, \Delta H = 242.3 kJmol^{-1}$

(b) $I_{2(g)} \rightarrow 2I_{(g)}, \Delta H = 151.0 kJmol^{-1}$

(c) $ICl_{(g)} \rightarrow I_{(g)} + Cl_{(g)}, \Delta H = 211.3 kJmol^{-1}$

(d) $I_{2(s)} \rightarrow I_{2(g)}, \Delta H = 62.76 kJmol^{-1}$
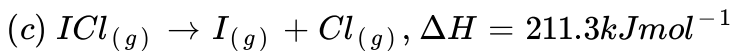
If standard state of iodine and chloride are $I_{2(s)}$ and $Cl_{2(g)}$, the standard enthalpy of formation for $ICl_{(g)}$ is :

A. $-14.6 kJmol^{-1}$

B. $-16.8 kJmol^{-1}$

C. $+16.8 kJmol^{-1}$

D. $+244.8 kJmol^{-1}$

Answer: C

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10. $(\Delta H - \Delta U)$ for the formation of carbon monoxide (CO) from its elements at $298K$ is

$(R = 8.314K^{-1}mol^{-1})$

A. $- 1238.78 Jmol^{-1}$

B. $1238.78 Jmol^{-1}$

C. $- 2477.57 Jmol^{-1}$

D. $2477.57 Jmol^{-1}$

Answer: B

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11. Assuming that water vapour is an ideal gas, the internal energy change

(ΔU) when 1 mole of water is vaporised at $1 bar$ pressure and $100°C$, (

given: molar enthalpy of vaporization of water $41 kJmol^{-1}$ at $1 bar$ and

$373K$ and $R = 8.3 Jmol^{-1}K^{-1})$ will be :

A. $4.100 kJmol^{-1}$

B. $3.7904 kJmol^{-1}$

C. $37.904 kJmol^{-1}$

D. $41.00 kJmol^{-1}$

Answer: C

---

12. Identify the correct statement regarding a spontaneous process :

A. For a spontaneous process in an isolated system, the change in entropy is positive

B. Endothermic processes are never spontaneous

C. Exothermic processes are always spontaneous

D. Lowering of energy in the reaction process is the only criterion for spontanity

Answer: A

13. In a fuel cell methanol is used as fuel and oxygen gas is used as an oxidizer. The reaction is :

$$CH_3OH_{(l)} + \frac{3}{2}O_{2(g)} \rightarrow CO_{(g)} + 2H_2O_{(l)}$$
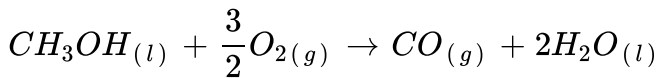
At $298K$ standard Gibb's energies of formation for $CH_3OH(l)$, $H_2O(l)$ and $CO_2(g)$ are -166.2, -237.2 and $-394.4 kJmol^{-1}$ respectively. If standard enthalpy of combustion of methanol is $-726kJmol^{-1}$, efficiency of the fuel cell will be :

A. 80 %

B. 87 %

C. 90 %

D. 97 %

Answer: D

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14. On the basis of the following thermochemical data :

$$\left(\Delta_f G^\circ H^+_{(aq.)} = 0\right)$$

$$H_2O_{(l)} \rightarrow H^+_{(aq.)} + OH^-_{(aq.)}, \Delta H = 57.32kJ$$

$$H_{2(g)} + \frac{1}{2}O_{2(g)} \rightarrow H_2O_{(l)}, \Delta H = -286.20kJ$$
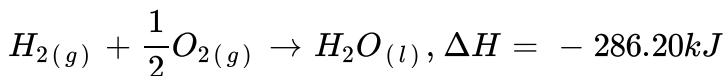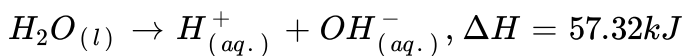
The value of enthalpy of formation of OH^- ion at $25^\circ C$ is :

A. $-22.88kJ$

B. $-228.88kJ$

C. $+228.88kJ$

D. $-343.52kJ$

Answer: B

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15. For which change $\Delta H \neq \Delta U$?

A. $H_{2(g)} + (I)_{2(g)} \Leftrightarrow 2HI_{(g)}$

B. $HCl_{(aq.)} + NaOH_{(aq.)} \rightarrow NaCl_{(aq.)} + H_2O_{(l)}$

C. $C_{(s)} + O_{2(g)} \Leftrightarrow CO_{2(g)}$

D. $N_{2(g)} + 3H_{2(g)} \rightarrow 2NH_{3(g)}$
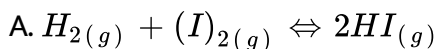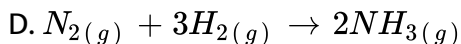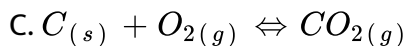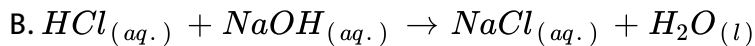
Answer: D

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16. Molar heat capacity of water in equilibrium with the ice at constant pressure is :

A. zero

B. infinity (∞)

C. $40.45.45 kJK^{-1}mol^{-1}$

D. $75.48 JK^{-1}mol^{-1}$

Answer: B

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17. Standard molar enthalpy of formation of CO_2 is equal to :

A. zero

B. the standard molar enthalpy of combustion

C. the sum of standard molar enthalpies of formation of CO and O_2

D. the standard molar enthalpy of combustion of carbon (graphite)

Answer: D

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18. Δ_f° for $CO_{2(g)}$, $CO_{(g)}$ and $H_2O_{(g)}$ are -393.5, -110.5 and $-241.8 kJmol^{-1}$ respectively. The standard enthalpy change (in kJ) for given reaction is :

$CO_{2(g)} + H_{2(g)} \rightarrow CO_{(g)} + H_2O_{(g)}$
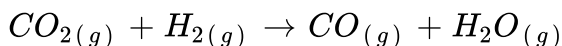
A. $+524.1$

B. $+41.2$

C. -262.5

D. -41.2

Answer: B

19. Which of the reaction defines $\Delta_f H^\circ$?

A. $C_{(diamond)} + O_2 \rightarrow CO_{2(g)}$

B. $\dfrac{1}{2}H_{2(g)} + \dfrac{1}{2}F_{2(g)} \rightarrow HF_{(g)}$

C. $N_{2(g)} + 3H_{2(g)} \rightarrow 2NH_{3(g)}$

D. $CO_{(g)} + \dfrac{1}{2}O_{2(g)} \rightarrow CO_{2(g)}$
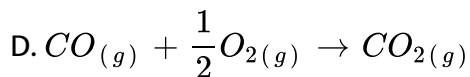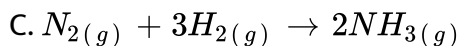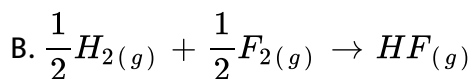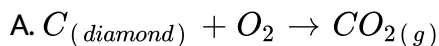
Answer: B

20. Using the data provided, calculate the multiple bond energy $(kJmol^{-1})$ of a $C \equiv C$ bond in C_2H_2. That energy is (take the bond energy of a $X - H$ bond as $350kJmol^{-1}$).

$2C_{(s)} + H_{2(g)} \rightarrow C_2H_{2(g)}, \Delta = 225kJmol^{-1}$

$2C_{(g)} \rightarrow 2C_g), \Delta H = 1410kJmol^{-1}$

$H_{2(g)} \rightarrow 2H_{(g)}, \Delta H = 330kJmol^{-1}$
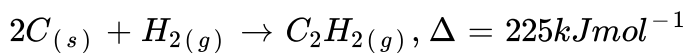
A. 1165

B. 837

C. 865

D. 815

Answer: D

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21. The incorrect expression among the following is :

A. in isothermal process, $w_{reversible} = -nRT \ln \dfrac{V_f}{V_i}$

B. $\ln K = \dfrac{\Delta H^\circ - T\Delta S^\circ}{RT}$

C. $K = e^{-\Delta G / RT}$

D. $\dfrac{\Delta G_{system}}{\Delta S_{total}} = -T$

Answer: B

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Exercise 6 Interger Answer Type Problem

1. Calculate the enthalpy change when infinitely dilute solutions of $CaCl_2$ and Na_2CO_3 are mixed. $\Delta_f H^\circ$ for $Ca^{2+}_{(aq.)}$, $CO^{2-}_{3(aq.)}$ and $CaCO_{3(s)}$ are -129.80, -161.65 and $288.46 kcal / mol$ respectively.

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2. Calculate the heat of transition for carbon from the following:

$$C_{\text{Diamond}} + O_2 \rightarrow CO_2(g), \Delta H = -94.3 kcal$$

$$C_{\text{Amorphous}} + O_2 \rightarrow CO_2(g), \Delta H = -97.6 kcal$$
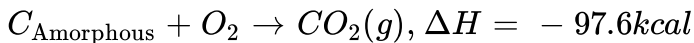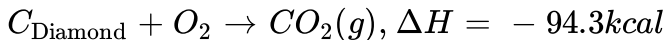
Also calculate the heat required to change $1g$ of C_{Diamond} to $C_{\text{Amorphous}}$.

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3. The enthalpy change involved in the oxidation of glucose is $-3000 kJmol^{-1}$. 25% of this energy is available for muscular work. If $100 kJ$ of muscular work is needed to walk 1 kilometer, what is the maximum distance that a person will be able to walk after eating $144g$ flucose ?

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4. The heat of combustion of ethane gas is $368 \times 10^3 calmol^{-1}$. If 62 per cent of heat is useful, how many m^3 of ethane measured at STP must be burnt to supply enough heat to convert $50kg$ of water at $10°C$ to steam

at $100°C$? Specific heat and heat of vaporisation of water are $1 cal/g$ and $540 cal/g$ respectively.

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5. The combustion of $10g$ coke raised to temperature of $1.0kg$ water from $10°C$ to $50°C$. Calculate the fuel value of cock. ($Sp.$ heat of $H_2O = 1 cal/g$).

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6. Lattice energy of $NaCl_{(s)}$ is $-788 kJmol^{-1}$ and enthalpy of hydration is $-784 kJmol^{-1}$. Calculate the heat of solution of $NaCl_{(s)}$.

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7. An intimate mixture of Fe_2O_3 and Al is used in solid fuel rocket. ΔH of Al_2O_3 and Fe_2O_3 are $399 kcal$ and $199 kcal$ respectively. Calculate the

fuel value in $kcalg^{-1}$ of mixture.

8. In above question7, if the density of Fe_2O_3 and Al are $5.2g/mL$ and $2.7g/mL$ respectively. Calculate the fuel value in $kcalmL^{-1}$ of mixture.

Exercise 7 Comprehension Based Objective Problems

1. Heat of reaction is the change in enthalpy or internal energy as represented by a balanced thermochemical equation . The amount of energy released during a chemical change depends upon the state of reactants and products, the conditions of pressure and volume at which reaction is carried out, and temperature. The variation of heat of reaction $(\Delta H_1$ or $\Delta E)$ with temperature is given as

$$\Delta H_2 - \Delta H_1 = \Delta C_P[T_2 - T_1] \text{ or } \Delta E_2 - \Delta E_1 = \Delta C_v(T_2 - T_1).$$

Standard heat enthalpy of elements in their most stable state is assumed to be zero whereas standard heat enthalpy of compound is referred as heat of formation of that compound at $1atm$ pressure and $25°C$. Oxidation of N_2 to N_2O, NO, NO_2 shows absorption of energy whereas heat of combustion of N_2 is exothermic like other heat of combustion. Standard heat enthalpy has been assumed to be zero for :

A. graphite

B. diamond

C. charcoal

D. lamp black

Answer: A

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2. Heat of reaction is the change in enthalpy or internal energy as represented by a balanced thermochemical equation . The amount of energy released during a chemical change depends upon the state of

reactants and products, the conditions of pressure and volume at which reaction is carried out, and temperature. The variation of heat of reaction $(\Delta H_1$ or $\Delta E)$ with temperature is given as

$$\Delta H_2 - \Delta H_1 = \Delta C_P[T_2 - T_1] \text{ or } \Delta E_2 - \Delta E_1 = \Delta C_v(T_2 - T_1).$$

Standard heat enthalpy of elements in their most stable state is assumed to be zero whereas standard heat enthalpy of compound is referred as heat of formation of that compound at $1atm$ pressure and $25°C$. Oxidation of N_2 to N_2O, NO, NO_2 shows absorption of energy whereas heat of combustion of N_2 is exothermic like other heat of combustion.

Which statements regarding the formation of NO and NO_2 respectively from N_2 and O_2 are correct ?

(1) Heat of formation of NO is exothermic

(2) Heat of formation of NO_2 is exothermic

(3) The oxidation of N_2 to NO and NO_2 is favoured at high temperature.

(4) If heat of formation of NO to NO_{92}) are 21.55 and $8.50kcal$, heat of reaction for

$$NO + \frac{1}{2}O_2 \rightarrow NO_2 \text{ is } -13.05kcal$$

A. 1, 2

B. 3, 4

C. 1, 2, 4

D. 1, 2, 3

Answer: b

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3. Heat of reaction is the change in enthalpy or internal energy as represented by a balanced thermochemical equation . The amount of energy released during a chemical change depends upon the state of reactants and products, the conditions of pressure and volume at which reaction is carried out, and temperature. The variation of hea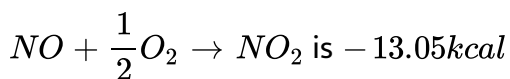t of reaction $(\Delta H_1$ or $\Delta E)$ with temperature is given as $\Delta H_2 - \Delta H_1 = \Delta C_P[T_2 - T_1]$ or $\Delta E_2 - \Delta E_1 = \Delta C_v(T_2 - T_1)$. Standard heat enthalpy of elements in their most stable state is assumed to be zero whereas standard heat enthalpy of compound is referred as heat of formation of that compound at $1atm$ pressure and $25°C$.

Oxidation of N_2 to N_2O, NO, NO_2 shows absorption of energy whereas heat of combustion of N_2 is exothermic like other heat of combustion. Heat of combustion of carbon in diamond and amorphous form ar -94.3 and $-97.6 kcal/mol$. The heat required to convert $6g$ carbon from diamond to amorphous form is :

A. $-1.65 kcal$

B. $+1.65 kcal$

C. $-3.3 kcal$

D. $+3.3 kcal$

Answer: a

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4. Heat of reaction is the change in enthalpy or internal energy as represented by a balanced thermochemical equation . The amount of energy released during a chemical change depends upon the state of reactants and products, the conditions of pressure and volume at which

reaction is carried out, and temperature. The variation of heat of reaction $(\Delta H_1$ or $\Delta E)$ with temperature is given as

$$\Delta H_2 - \Delta H_1 = \Delta C_P[T_2 - T_1] \text{ or } \Delta E_2 - \Delta E_1 = \Delta C_v(T_2 - T_1).$$

Standard heat enthalpy of elements in their most stable state is assumed to be zero whereas standard heat enthalpy of compound is referred as heat of formation of that compound at $1atm$ pressure and $25°C$. Oxidation of N_2 to N_2O, NO, NO_2 shows absorption of energy whereas heat of combustion of N_2 is exothermic like other heat of combustion. Heat of vaporisation of H_2O is $627.78 cal/g$. If heat of formation of $H_2O_{(l)}$ is $-68.3 kcal$, heat of formation of $H_2O_{(g)}$ is :

A. $-57.0 kcal$

B. $559.5 kcal$

C. $676.73 kcal$

D. cannot be calculated

Answer: a

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5. Heat of reaction is the change in enthalpy or internal energy as represented by a balanced thermochemical equation . The amount of energy released during a chemical change depends upon the state of reactants and products, the conditions of pressure and volume at which reaction is carried out, and temperature. The variation of heat of reaction $(\Delta H_1 \text{ or } \Delta E)$ with temperature is given as $\Delta H_2 - \Delta H_1 = \Delta C_P[T_2 - T_1]$ or $\Delta E_2 - \Delta E_1 = \Delta C_v(T_2 - T_1)$. Standard heat enthalpy of elements in their most stable state is assumed to be zero whereas standard heat enthalpy of compound is referred as heat of formation of that compound at $1atm$ pressure and $25°C$. Oxidation of N_2 to N_2O, NO, NO_2 shows absorption of energy whereas heat of combustion of N_2 is exothermic like other heat of combustion. The specific heat of I_{20} in vapour and solid state are 0.031 and $0.55 cal/g$ respectively. If heat of sublimation of iodine is $6.096 kcalmol^{-1}$ at $200°C$, the heat of sublimation of I_2 at $250°C$ is :

A. $5.8 kcalmol^{-1}$

B. $2.28 kcalmol^{-1}$

C. $4.8 kcal mol^{-1}$

D. $3.8 kcal mol^{-1}$

Answer: a

6. Heat of neuralisation is amount of heat evolved or absorbed when $1g-$ equivalent of an acid reacts with $1g-$ equivalent of a base in dilute solution . If weak acid or weak bae are neutralised, the heat released during neutralisation is somewhat lesser than $-13.7 kcal$ or $-57.27 kJ$. Het of neutralisation is also referred as heat of formation of water   from H^+ and OH^- ions

$i.\,e.\,,\ H^+ + OH^- \rightarrow H_2O, \Delta H = -13.7 kcal.$

Heat of neutralisatio of HF and acetic acid respectively are (in $kcal$):

A. $> -13.7, \leftarrow 13.7$

B. $> -13.7, < -13.7$

C. $\leftarrow 13.7$

D. $\leftarrow 13.7, \; > \; -13.7$

Answer: b

7. Heat of neuralisation is amount of heat evolved or absorbed when $1g -$ equivalent of an acid reacts with $1g -$ equivalent of a base in dilute solution . If weak acid or weak bae are neutralised, the heat released during neutralisation is somewhat lesser than $-13.7 kcal$ or $-57.27 kJ$. Het of neutralisation is also referred as heat of formation of water from H^+ and OH^- ions $i.e., H^+ + OH^- \rightarrow H_2O, \Delta H = \; -13.7 kcal.$

Which of the following statements are correct ?

(1) $\Delta H = \Delta U + \Delta n RT$

(2) Heat changes measured by bomb calorimeter give change in heat enthalpy during the reaction.

(3) $\Delta H = \Delta U$ for the reaction :

$$C_{(s)} + O_{2(g)} \rightarrow CO_{2(g)}$$

(4) Heat of formation for C_6H_6 can be directly measured.
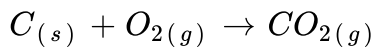
A. 2, 3

B. 1, 4

C. 1, 2, 3

D. 1, 3

Answer: D

8. Heat of neuralisation is amount of heat evolved or absorbed when $1g -$ equivalent of an acid reacts with $1g -$ equivalent of a base in dilute solution . If weak acid or weak bae are neutralised, the heat released during neutralisation is somewhat lesser than $-13.7kcal$ or $-57.27kJ$. Het of neutralisation is also referred as heat of formation of water from H^+ and OH^- ions

$i.\,e.\,,\,H^+ + OH^- \rightarrow H_2O,\, \Delta H = -13.7kcal.$

$200mL$ of $0.1MNaOH$ is mixed with $100mL$ of $0.1MH_2SO_4$ in 1 experiment. In II experiment $100mL$ of $0.1MNaOH$ is mixed with $50mL$ of $0.1MH_2SO_4$. Select the correct statements:

(1) heat liberated in each of the two reactions is $274cal$.

(2) heat liberated in I is $274cal$ and in II is $137cal$. ,brgt (3) temperature rise is I reaction is equal to the temperature rise in II.

(4) temperature rise in I reaction is equal to the temperaure rise in II

A. 1, 3

B. 2, 4

C. 2, 3

D. 1, 4

Answer: b

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9. Hess's law of heat of summatiion is based on law of conservation of energy. It has found significance in deriving heats of many reactions

which either do not take place or if take place, than other side reactions also accompany it. For example heat of reaction for $C + \frac{1}{2}O_2 \rightarrow CO$ can not be studied directly as it occurs with simultaneous reaction of oxidation of CO to CO_2. Bond energy is referred as heat enthalpy when a bond is broken to produce isolated gaseous atoms. In case of breaking up of bonds between unlike atoms e. g. , $C - H$ bond in CH_4 , bond energy is referred as avarage bond energy as four $C - H$ bonds are broken up.

Which of the following statements are correct ?

(1) The dissociation of a ond is always endothermic

(2) The formation of a bond is always exothermic.

(3) Heat of formation of an atom $= 1/2 \times$ bond energy like atoms covalent bond.

(4) The heat enthalpy change in a chemical reaction is equal but opposite to the heat enthalpy if reaction is reversed.

(5) Hess's law can be verified experimentally.

    A. 1, 2, 3, 4

    B. 1, 2, 3, 4, 5

C. 2, 3, 4, 5

D. 3, 4, 5

Answer: a

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10. Hess's law of heat of summatiion is based on law of conservation of energy. It has found significance in deriving heats of many reactions which either do not take place or if take place, than other side reactions also accompany it. For example heat of reaction for $C + \frac{1}{2}O_2 \to CO$ can not be studied directly as it occurs with simultaneous reaction of oxidation of CO to CO_2 . Bond energy is referred as heat enthalpy when a bond is broken to produce isolated gaseous atoms. In case of breaking up of bonds between unlike atoms $e.\,g.$, $C - H$ bond in CH_4 , bond energy is referred as avarage bond energy as four $C - H$ bonds are broken up.

Heat of dissociation of CH_4 and C_2H_6 are 360 and $620 kcal mol^{-1}$. The $C - C$ bond energy would be :
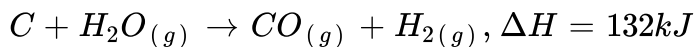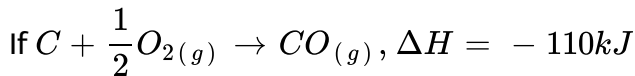
A. $60kcal$

B. $80kcal$

C. $100kcal$

D. $40kcal$

Answer: b

11. Hess's law of heat of summatiion is based on law of conservation of energy. It has found significance in deriving heats of many reactions which either do not take place or if take place, than other side reactions also accompany it. For example heat of reaction for $C + \dfrac{1}{2}O_2 \rightarrow CO$ can not be studied directly as it occurs with simultaneous reaction of oxidation of CO to CO_2 . Bond energy is referred as heat enthalpy when a bond is broken to produce isolated gaseous atoms. In case of breaking up of bonds between unlike atoms $e. g. , C - H$ bond in CH_4 , bond energy is referred as avarage bond energy as four $C - H$ bonds are

broken up.

If $C + \dfrac{1}{2}O_{2(g)} \rightarrow CO_{(g)}, \Delta H = -110kJ$

$C + H_2O_{(g)} \rightarrow CO_{(g)} + H_{2(g)}, \Delta H = 132kJ$

The mole composition of mixture of steam and O_2 and steam on being passed over coke at $1273K$ so that temperature remains constant is :

A. $0.6 : 1$

B. $1.67 : 1$

C. $0.3 : 1$

D. $0.4 : 1$

Answer: a

12. Hess's law of heat of summatiion is based on law of conservation of energy. It has found significance in deriving heats of many reactions which either do not take place or if take place, than other side reactions also accompany it. For example heat of reaction for $C + \dfrac{1}{2}O_2 \rightarrow CO$

can not be studied directly as it occurs with simultaneous reaction of oxidation of CO to CO_2 . Bond energy is referred as heat enthalpy when a bond is broken to produce isolated gaseous atoms. In case of breaking up of bonds between unlike atoms $e.\,g.\,,\,C-H$ bond in CH_4 , bond energy is referred as avarage bond energy as four $C-H$ bonds are broken up.

The heat of fusion for water is $+1.44kcal$. The heat requried to change $27g$ ice at $0^\circ C$ to water is :

A. $2.16kcal$

B. $0.72kcal$

C. $25.92kcal$

D. $2.88kcal$

Answer: a

Exercise 8 Statement Explanation Type Problems

1. Statement : Heat of combustion are always exothermic.

Explanation : Combustio of N_2 to give NO is exothermic.

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2. Statement : Combustion of N_2 to give NO is endothermic

Explanation : Bond energy of N_2 is very high.

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3. Statement : Standard heat enthalpy of a compound is its heat of formation at $25^\circ C$ and $1 atm$

Explanation : Standard heat enthalpy of pure elements have arbitrarily assumed to be zero.

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4. Statement: The variation of heat of reaction with temperature are given in terms of Kirchhoff's equation.

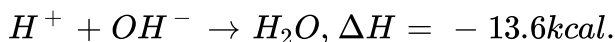Explanation : The kirchhoff's equation is : $\Delta H = \Delta U + \Delta nRT$

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5. Statement : The ratio of heat of vaporisation and the normal boiling point of a liquid is approximately $88 J/mol$.

Explanation : This is Trouton's rule derived by experimental data.

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6. Statement : Heat of neutralisation can be given as :

$H^+ + OH^- \rightarrow H_2O, \Delta H = -13.6 kcal.$

Explanation : Heat of neutralisation can be alternatively defined as heat of formation of water.

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7. Statement : Heat of neutration for HF is $-68.552kJ/eq.$ whereas for HCl it is $-57.26kJ/eq.$

Explanation : The acid HF is weak acid.

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8. Statement : In a diatomic molecule involving two like atoms covalently bonded with each other , bond energy $= 2 \times$ heat of formation of atom.

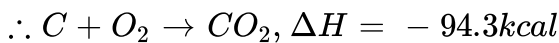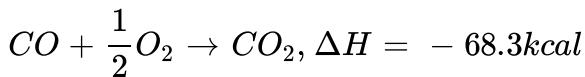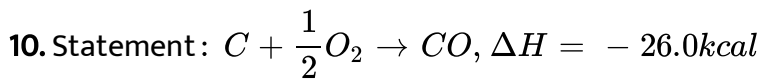Explanation : $H_2 \rightarrow 2H, e_{H-H} = \Delta H$

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9. Statement : Bond energy for breaking up a bond is endothermic

Explanation : Heat is required to overpower the attractions between two atoms.

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10. Statement : $C + \dfrac{1}{2}O_2 \rightarrow CO, \Delta H = -26.0 kcal$

$CO + \dfrac{1}{2}O_2 \rightarrow CO_2, \Delta H = -68.3 kcal$

$\therefore C + O_2 \rightarrow CO_2, \Delta H = -94.3 kcal$

Explanation : This is an experimental proof of Hess's law.

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Exercise 9 Advance Numerical Problems

1. The heat of reaction for,

$C_{10}H_{8(s)} + 12O_{2(g)} \rightarrow 10CO_{2(g)} + 4H_2O_{(l)}$ at constant volume is

$-1228.2 kcal$ at $25°C$. Calculate the heat of reaction at constant

pressure at $25°C$.

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2. The heat of reaction for $N_2 + 3H_2 \rightarrow 2NH_3$ at $27°C$ is $-91.94 kJ$.

What will be its value at $50°C$? The molar heat capacities at constant

pressure and $27°C$ for N_2, H_2 and NH_3 are 28.45, 28.32 and 37.07 joule respectively.

3. The heat evolved in the conversion of $1g-$ atom of $\beta-$ sulphur into $alph-$ sulphur is $82cal$ at $25°C$. If the specific heats of $\alpha-$ and $\beta-$ sulphur are 0.163 and $0.171cal/g$, calculate the heat of transition for $\beta-$ sulphur into $\alpha-$ sulphur at $50°C$.

4. Since their discovery in 1985 , fullerenes have received the attention of many chemical researchers. In a recentrly reported data, the specific internal energy of combustion of crystalline C_{60} is found to be $-36kJg^{-1}$ at $298K$. Compute the standard enthalpy of combustion and formation for the same. Standard enthalpy of combustion of graphite is $-395kJmol^{-1}$. If the standard enthalpy of formation of diamond is $+2kJpermol$ of $C-$ atom, which is more stable : C_{60} or diamond ?

5. The heat evolved on combustion of $1g$ starch $(C_6H_{10}O_5)_n$ into CO_2 and $H_2O_{(l)}$ is $17.49kJg^{-1}$. Compute the enthalpy of formation of $1g$ starch. Given, ΔH_f of $H_2O_{(l)} = -285.85kJmol^{-1}$, ΔH_f of $CO_2 = -293.7kJmol^{-1}$.

6. Given the following standard heats of reactions:

(a) heat of formation of water $= -68.3kcal$, (b) heat of combustion of $C_2H_2 = -310.6kcal$, (c) heat of combustion of ethylene $= -337.2kcal$. Calculate the heat of reaction for the hydrogenation of acetylene at constant volume and at $25°C$.

7. Calculate the heat of neutralisation from the following data:

$200mL$ of $1MHCI$ is mixed with $400mL$ of $0.5MNaOH$. The temperature rise in calorimeter was found to be $4.4°C$. Water equivalent of calorimeter is $12g$ and specific heat is $1calmL^{-1}degree^{-1}$ for solution.

8. The enthalpies of neutralisation of a string acid HA and a weaker acid HB by $NaOH$ are -13.7 and $-12.7kcalEq^{-1}$, respectively. When one equivalent of $NaOH$ is added to a mixture containing one equivalent of HA and HB, the enthalpy change was $-13.5kcal$. In what ratio is the base distributed between HA and HB?

9. Two solutions initially at $25°C$ were mixed in an insulated bottle. One contains $400mL$ of $0.2N$ weak monoprotic acid solution. The other

contains $100mL$ of $0.8NNaOH$ solution. After mixing the temperature

rises to $26.17°C$. Calculate the heat of neutralisation of weak acid with

$NaOH$. Assume density of final solution $1.0gcm^{-3}$. and speicific heat of

final solution $4.2Jg^{-1}K^{-1}$.

10. A monobasic acid is dissociated to 25% in $0.1N$ solution. When

$100mL$ of the acid is neutralised by $0.1NKOH$ solution, heat evolved

was $120cal.$ Calculate heat of dissociation per mole of acid.

11. The dissolution of $1mole$ of $NaOH_{(s)}$ in $100mole$ of $H_2O_{(l)}$ give rise

to evolution of heat equal to $-42.34kJ$. However if $1mole$ of $NaOH_{(s)}$

is dissolved in $1000mole$ of $H_2O_{(l)}$, the heat given out is $42.76kJ$. What

would be enthalpy change when 900 mole of $H_2O_{(l)}$ are added to a

solution containing 1 mole of $NaOH_{(s)}$ in 100 mole of H_2O ?

12. The integral enthalpy of solution in kJ of one mole of H_2SO_4 dissolved in n mole of water is given by :

$$\Delta H_s = \frac{75.6 \times n}{n + 1.8}$$

Calculate ΔH for the following processes :

(a) 1 mole of H_2SO_4 dissolved in 2 mole of H_2O.

(b) 1 mole of H_2SO_4 dissolved in 7 mole of H_2O.

(c) 1 mole of H_2SO_4 dissolved in 5 mole of H_2O.

(d) solution (a) dissolved in 5 mole of H_2O.

(e) 1 mole of H_2SO_4 dissolved in excess of H_2O.

13. The heat of solution of NH_4NO_3 in water was determined by measuring the amount of electrical work needed to compensate for the cooling which the NH_4NO_3 was added to the water, electrical energy was provided by passage of current through a resistance coil until the

temperature of the solution reached the value it had prior to the addition of salt. In a typical experiment, $4.4g$ of NH_4NO_3 was added to $200g$ water. A current of 0.75 ampere was provided through the heater coil , and the voltage across the terminals was $6.0V$. The current was applied for 5.2 minute. Calculate ΔH for the solution of $1.0 mole NH_4NO_3$ in enough water to give same concentration as was attained in the above experiment.

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14. An athelet takes 20 breaths per minute at room temperature. The air inhaled in each breath is $200mL$ which contains 20% oxygen by volume, while exhaled air contains 10% oxygen by volume. Assuming that al the oxygen consumed if used for converting glucose into CO_2 and $H_{92})O_{(l)}$, how much glucose will be burnt in the body in one hour and what is the heat produced ? (Room temperature $-27°C$ and enthalpy of combustion of glucose is $-2822.5 kJmol^{-1} at 0°C)$

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15. A slice of banana weighing $2.502g$ was burnt in a bomb calorimeter producing a temperature rise of $3.05°C$. The combustion of $0.316g$ of benzoic acid in the same calorimeter produced a temperature rise of $3.24°C$. The heat of combustion of benzoic acid at constant volume is $-3227kJmol^{-1}$. If average banana weigh $125g$, how many calories can be obtained from one average banana ?

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16. A person inhales $640g$ of O_{20} per day. If all the O_2 is used for converting sugar into CO_2 and H_2O, how much sucrose $(C_{12}H_{22}O_{11})$ is consumed in the body in one day and what is the heat evolved ? $\left(\Delta H_{\text{combination of sucrose}} = -5645kJmol^{-1}\right)$

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17. The heat of formation of carbon dioxide from graphite at $15°C$ and constant volume is $97400cal$, and that of carbon monoxide under the

same conditions is $25400cal$. What heat should be evolved when 100 litre of carbon monoxide measured at $N.T.P.$ is burnt in an excess of oxygen, both reactants and products being at $15°C$?

18. When $12.0g$ of carbon reacted with oxygen to form CO and CO_2 at $25°C$ and constant pressure, $75.0kcal$ of heat was liberated and no carbon remained . Calculate the mass of oxygen which reacted.

$$\left(\Delta H_f^\circ (CO_2) = -95kcalmol^{-1}, \Delta H_f^\circ (CO) = -24kcalmol^{-1}\right)$$
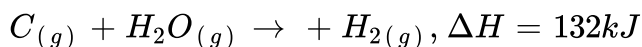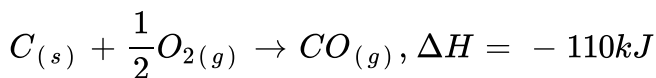
19. The heat of combustion of ethane gas is $368kcal/mol$. Assuming that 60% of the heat is useful, how many m^3 of ethane 9 measured at STP) must be burnt to supply enough heat to convert $50kg$ of water at $10°C$ to steam at $100°C$? Specific heat of water is $1cal/g$. Heat of vaporisation of H_2O is $540cal/g$.

20. The commercial production of water gas utilizes the reaction under standard conditions : $C + H_2O_{(g)} \rightarrow H_2 + CO$. The heat required for this endothermic reaction may be supplied by adding a limited amount of air and burning some carbon to CO_{20}. How many gram of carbon must be burnt to CO_2 to provide enough heat for the water gas conversion of $100g$ carbon ? Neglect all heat losses to the environment. Also ΔH_f° of $CO, H_2O_{(g)}$ and CO_2 are $-110.53, -241.81$ and $-393.51 kJ/mol$ respectively.

21. From the following data of ΔH, of the following reaction,

$$C_{(s)} + \frac{1}{2}O_{2(g)} \rightarrow CO_{(g)}, \Delta H = -110kJ$$

$$C_{(g)} + H_2O_{(g)} \rightarrow + H_{2(g)}, \Delta H = 132kJ$$

Calculate the mole composition of the mixture of steam and oxygen on being passed over coke at $1273K$, keeping temperature constant.

**22.** When $100c.\,c.$ of a mixture of methane (CH_4) and ethylene (C_2H_4) was exploded with an excess of oxygen , the volume of carbon dioxide produced (measured at the same temperature and pressure) was $160c.\,c.$ Calculate the heat evolved when 22.4 litre of the mixture of methane and ethylene (measured at $N.\,T.\,P.$) is completely oxidised to carbon dioxide and water at constant volume.

$$CH_4 + 2O_2 = CO_2 + 2H_2O + 212000cal,$$

$$C_2H_4 + 3O_2 = 2CO_2 + 2H_2O + 333000cal.$$
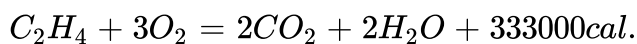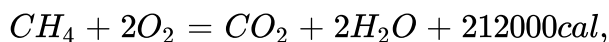
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23. $1.0g$ magnesium atoms in vapour phase absorbs $50.0kJ$ of energy to convert all Mg into Mg ions. The energy absorbed is needed for the following changes :
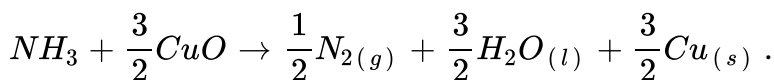
$$Mg_{(g)} \rightarrow Mg^+_{(g)} + e, \Delta H = 740kJmol^{-1}$$

$$Mg^+_{(g)} \rightarrow Mg^{2+}_{(g)} + e, \Delta H = 1450kJmol^{-1}$$
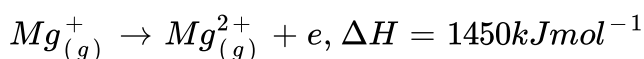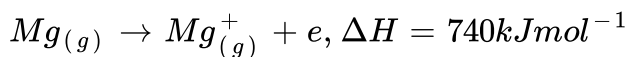
Find out the % of Mg^+ and Mg^{2+} in final mixture.

24. Calculate the enthalpy change when $6.80g$ of NH_3 is passed over heated CuO. The standard heat enthalpies of $NH_{3(g)}$, $CuO_{(s)}$ and $H_2O_{(l)}$ are -46.0, -155.0 and $-285.0 kJmol^{-1}$ respectively and the change is

$$NH_3 + \frac{3}{2}CuO \rightarrow \frac{1}{2}N_{2(g)} + \frac{3}{2}H_2O_{(l)} + \frac{3}{2}Cu_{(s)} \ .$$

25. $1.00litre$ sample of a mixture of $CH_{4(g)}$ and $O_{2(g)}$ measured at $25°C$ and $740t$ or r was allowed to react at constant pressure in a calorimeter which together with its contents had a heat capacity of $1260cal/K$. The complete combustion of the methane toCO_2 and H_2O caused a temperature rise in the calorimeter of $0.667K$. What was the mole per cent of CH_4 in the original mixture ?

$$\left(\Delta H_{comb.}^{°}(CH_4) = -215kcalmol^{-1}\right)$$

26. The standard enthalpy of formation of FeO and Fe_2O_3 is $-65 kcal mol^{-1}$ and $-197 kcal mol^{-1}$ respectively. A mixture of two oxides contains FeO and Fe_2O_3 in the mole ratio $2:1$. If by oxidation, it is changed into a $1:2$ mole ratio mixture, how much of thermal energy will be released per mole of initial mixture ?

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27. When $120 mg$ of naphthalene $C_{10}H_{8(s)}$ was burnt in a bomb calorimeter, the temperature rise was $3.05K$. Calculate the calorimeter constant and molar standard internal energy change of combustion. Also report by how much will the temperature rise when $100 mg$ of Phenol $\left(C_6H_5OH_{(s)}\right)$ is burnt in the same calorimeter under the same conditions, if heat liberated is $3962.85J$?

$\left(\Delta H_C^\circ \, for \, C_{10}H_8 \, = \, -5157 kJ mol^{-1}\right)$

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28. The heat of dissociation of H_{20} is $435kJmol^{-1}$. If $C_{(s)} \rightarrow C_{(g)}$, $\Delta H = 720kJmol^{-1}$, calculate the bond energy per mole of the $C - H$ bond in CH_4 molecule . $\left(\Delta H_f for CH_4 = -75kJmol^{-1}\right)$

29. The heat of combustion of acetylene is $312kcal$. If heat of formation of CO_2 and H_2O are 94.38 and $68.38kcal$ respectively. Calculate $C \equiv C$ bond energy. Given that heat of atomisation of C and H are 150.0 and $51.5kcal$ respectively and $C - H$ bond energy is $93.64kcal$.

30. Calculate the resonance energy of C_6H_6 using Kerkule formula for C_6H_6 from the following data.

(i) $\Delta H_f^{\circ} for C_6H_6 = -358.5kJmol^{-1}$

(ii) Heat of atomisation of $C = 716.8kJmol^{-1}$

(iii) Bond energy of $C - H, C - C, C = C$ and $H - H$ are $490, 340, 620, 436.9 kJmol^{-1}$ respectively.

31. The specific heat at constant volume for a gas $0.075 cal/g$ and at constant pressure is $0.125 cal/g$ Calculate :

(i) The molecular weight of gas,

(ii) Atomicity of gas,

(iii) No. of atoms of gas in its 1 mole.