

CHEMISTRY

BOOKS - R SHARMA CHEMISTRY (HINGLISH)

THERMODYNAMICS

Example

1. A certain gas undergoes constant temperature expansion from 264mL to 971mL . Calculate the work done in joules) by the gas if it expands (i) against a vacuum and (ii) against a constant pressure of 4 atm.

Strategy : Use to calculate the work done by the gas on the surrounding, i.e.,

$$w = -P\Delta V$$

where P is the opposing external atmospheric pressure and ΔV , the change in volume, is given by $V_f - V_i$, Also, convert the initial and final volumes in liters.



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2. Calculate the work associated with the vaporization of 1 mol of water is $373K$ and 1 atm. Assume ideal gas behavior.

Strategy : As liquid water absorbs heat, it forms vapor 1 atm pressure. As the amount of vapor increases, the piston rises. The value of ΔV is the difference in volume between the initial and final states of the system.

The final volume is the volume of one mole of water vapor at the specified conditions. We can find by using the ideal gas equation ($PV = nRT$).

The initial volume of 1 mol of liquid water

$[V = d. m = (1gmL^{-1})(18g) = 18mL]$ is negligible relative to the

volume of water vapor. In general the volume of liquid or solid can be

neglected in the calculation of ΔV because they are so much smaller than

the volume of the same amount of gas.



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3. The volume of a sample of an ideal gas contracts from $8.4L$ to $4.2L$ as a result of an applied pressure of 1.5 atm . The system also evolved $830J$ of heat during the contraction. Find ΔU for this change in state.

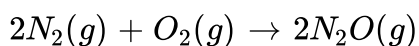
Strategy : According to , to find ΔU , we must know q and w . Since heat flows from system to surrounding, the value of q is given as $-830J$. The value of w can be calculated by

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4. While $1mol$ of ice melts at $0^\circ C$ and at constant pressure of $1atm$, $1440cal$ of heat are absorbed by the system. The molar volume of ice and water are 0.0196 and $0.0180L$ respectively. Calculate ΔH and ΔU .

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5. The value of ΔH for the reaction



at $298K$ is $164kJ$. Calculate ΔU for the reaction.

Strategy : In this process, 3 mol of gas change to 2 mol of gas at constant temperature and pressure. Assuming ideal gas behavior, we can use Δn_g and obtain a value of ΔU by converting the value of ΔH from $164kJ$ to $164000J$ and expressing R in units of $Jmol^{-1}K^{-1}$

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6. How much heat (in joule) is required to raise the temperature of 205g of water from $21.2^{\circ}C$ to $91.4^{\circ}C$. Specific heat of water is $4.18Jg^{-1}.^{\circ}C^{-1}$

Strategy : The specific heat of a substance is the amount of heat required to raise the temperature of 1g of the substance by $1^{\circ}C$.

Thus

Specific heat

$$= \frac{\text{(Amount of heat in joules)}}{\text{(Mass of substance in grams)}(\text{Temperature change in } ^{\circ}C)}$$

Rearrangement gives.

$$\text{Amount of heat } (q) = \text{Mass of substance } (m) \times \text{Specific heat } (c) \times \text{Temperature change } (\Delta T)$$

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7. A quantity of 1.534g of naphthalene ($C_{10}H_8$) is burned in constant-volume bomb calorimeter. Consequently, the temperature of the water rises from $20.00^\circ C$ to $25.00^\circ C$. If the quantity of water surrounding the calorimeter is exactly 3000g calculate the heat capacity of combustion of one mole of naphthalene (molar heat of combustion)

Strategy : First calculate the heat changes for the water and the bomb calorimeter. Finally, divide the value by the number of moles of naphthalene to calculate the molar heat of combustion. Remember to change $2.75kJ^\circ C^{-1}$ to $2.75 \times 1000J^\circ C^{-1}$

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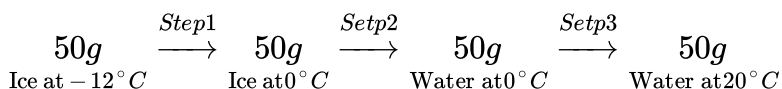
8. Calculate the amount of heat that must be absorbed by 5g of ice at $120^\circ C$ to convert it to water at $2^\circ C$. Use the specific heat of ice ($2.09Jg^{-1}^\circ C^{-1}$), enthalpy of fusion of ice ($334Jg^{-1}$), and specific heat of water ($4.18Jg^{-1}^\circ C^{-1}$) for calculation

Strategy : We must calculate the amount of heat absorbed during three

steps. Itbrgt (i) Warming 50g of ice from $-12^{\circ}C$ to its melting point $0^{\circ}C$. This requires the specific heat of ice.

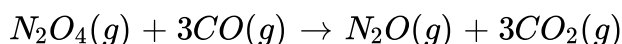
Melting the ice with no change in temperature . This needs the entholpy of fusion of ice at $0^{\circ}C$.

Warming the resulting liquid from $0^{\circ}C$ to $20^{\circ}C$. This requires specific heat of water



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9. Find the value of $\Delta_f H^{\circ}$ for the reaction



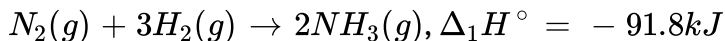
Standard enthalpies of formation of $CO(g)$, $CO_2(g)$, $N_2O(g)$, and $N_2O_4(g)$ are -110 , -393 , 81 , and $9.7kJmol^{-1}$, respectively.

Strategy : The standard enthalpy change of a reaction is equal to the sum of the standard molar enthalpie of formation of the products each multiplied by its stiochiometric coefficient in the balanced equation, minus the corresponding sum of the standard molar enthalpies of formation of the reactants



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10. How much heat is released when 850kg of ammonia is produced according to the following thermochemical equation?



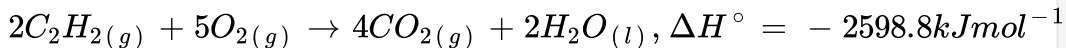
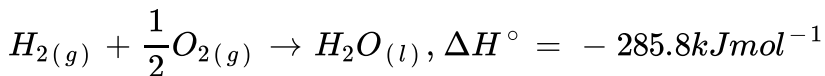
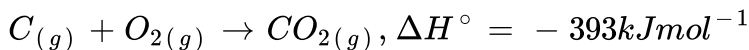
Strategy : To do the calculation, we must convert grams of NH_3 to moles of NH_3 , and then to kilojoules of heat.

Grams of $NH_3 \rightarrow$ Moles of $NH_3 \rightarrow$ Kilojoules of heat



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



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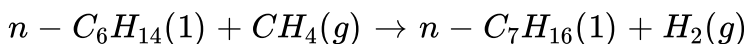
12. The combustion of 1 mol of benzene (C_6H_6) takes place at $298K$ and 1 bar pressure. After combustion, $CO_2(g)$ and $H_2O(l)$ are produced and $3267kJ$ of heat is liberated. Calculate the standard enthalpy of formation, $\Delta_f H^\circ$ of benzene. Standard enthalpies of formation of $CO_2(g)$ and $H_2O(l)$ are $-393.5kJmol^{-1}$ and $-258.83kJmol^{-1}$, respectively.

Strategy : Apply Eq. the mathematical form of Hess's law, to the combustion reaction of 1 mol of benzene. Remember $\Delta_f H^\circ$ for $O_2(g)$ is zero by convention. We are give $\Delta_f H^\circ$ and $\Delta_c H^\circ$ values for all substance except $C_6H_6(l)$. We can solve for this unknown.



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13. Predict $\Delta_f H^\circ$ for the reaction



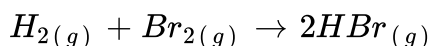
if the standard enthalpies of combustion are $-981.8 - 210.8$, -1149.4 , and $68.38kcalmol^{-1}$ for $n - C_6H_{14}$, CH_4 , $n - C_7H_{16}$, and H_2 ,

respectively, at $298K$.

Strategy : Use Hess's law in the form of Eq.

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14. Calculate the enthalpy change during the reaction :



Given, $e_{H-H} = 435kJmol^{-1}$, $e_{Br-Br} = 192kJmol^{-1}$ and

$$e_{H-Br} = 368kJmol^{-1}.$$

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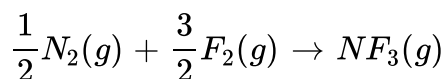
15. Using the data $\Delta_f H^\circ (NF_3, g) = -114kJmol^{-1}$,

$\Delta_{N\equiv N} H^\circ = 946kJmol^{-1}$, and $\Delta_{f-f} H^\circ = 158kJmol^{-1}$, calculate the

average bond enthalpy of $N-F$ bond in NF_3 .

Strategy : First write the thermochemical equation corresponding to

$\Delta_f H^\circ (NF_3, g)$:

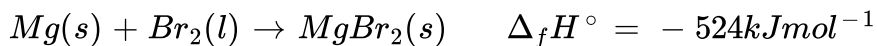


Now define $\Delta_r H^\circ$ of this reaction in terms of bonds made and bonds

broken. Notice the $1/2$ mol of $N \equiv N$ bonds and $3/2$ mol of $F - F$ bond are broken, while 3 mole of $N - F$ bonds are formed each NF_3 has three $N - F$ bonds: we are given the bond enthalpies of $N \equiv N$ and $F - F$ bonds, while the average bond enthalpy of $N - F$ bond is not known. Applying Eq. for the reaction, we can calculate this unknown.

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16. Calculate the lattice enthalpy of $MgBr_2$ from the given data:



Strategy : The thermochemical equation corresponding to lattice enthalpy of $MgBr_2$ is



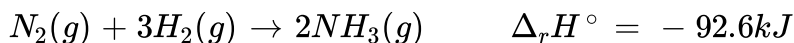
Add the last five thermochemical equations to the thermochemical equation corresponding to lattice enthalpy to get the thermochemical

equation for the formation of $MgBr_2(s)$ from its constituent element.

Finally, calculate $\Delta_{Lattice}H^\circ$, using the concept of Hess's law.

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17. Consider the synthesis of ammonia:



If absolute entropies of $N_2(g)$, $H_2(g)$, and $NH_3(g)$ are $192 \text{ J K}^{-1} \text{ mol}^{-1}$, $131 \text{ J K}^{-1} \text{ mol}^{-1}$, and 193 J K^{-1} , respectively, at 25° C , predict whether the reaction is spontaneous or not.

Strategy : Calculate ΔS_{univ} using ΔS_{says} and ΔS_{surr} . For calculating ΔS_{says} use the absolute entropies of reactants and product. For calculating ΔS_{surr} , use $\Delta_r H^\circ$ and T .

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Follow Up Test 1

1. Which of the following is a form of potential energy?

- A. Radiant energy
- B. Thermal energy
- C. Chemical energy
- D. Electrical energy

Answer: C



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2. Which of the following is not the application of thermodynamics?

- A. It helps to predict the feasibility of a process.
- B. It tells the speed of a process.
- C. It helps in predicting the extent of reversible reaction before equilibrium is attained.

D. It help of deduce some important laws.

Answer: B



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3. An isolated system can exchange_____ with its surrounding.

A. energy

B. mass

C. both energy and mass

D. neither energy nor mass

Answer: D



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4. Which of the following is not the unit of energy?

A. watt

B. joule

C. calorie

D. erg

Answer: A



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5. Which of the following is not a closed system

(i) Rocket engine during propulsion

(ii) Pressure cooker

(iii) Tea placed in a steel kettle

Jet engine

A. (i),(ii),(iii),(iv)

B. (ii),(iii),(iv)

C. (i),(ii),(iv)

D. (i),(ii),(iii)

Answer: C



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6. Which of the following is incorrect?

- A. A thermodynamic system refers to any part of the real world under study.
- B. Everything that is not a part of the system and can interact with it is called its surroundings.
- C. The surrounding can affect the system by the exchange of matter or energy.
- D. A system and its surrounding are always separated by real boundaries across which matter and energy may be exchanged.

Answer: D



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7. A well stoppered thermo flask containing some ice cubes is an example of

- A. isolated system
- B. cyclic system
- C. closed system
- D. open system

Answer: A



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8. The state of a thermodynamic system is described by is _____ properties.

- A. atomic

B. macroscopic

C. microscopic

D. none of these

Answer: B



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9. Which of the following variables are called state variables or state functions?

A. P

B. V

C. T

D. All of these

Answer: D



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10. When a thermodynamic system undergoes a change of _____, we say it has undergone a process.

(i) P

(ii) V

(iii) T

(iv) n

A. (i),(ii),(iii)

B. (ii),(iii),(iv)

C. (i),(ii),(iii),(iv)

D. (i),(ii)

Answer: C



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Follow Up Test 2

1. Which of the following are not state functions of state variables?

(i) Internal energy

(ii) Heat

(iii) Work

(iv) Volume

A. (i),(ii),(iii),(iv)

B. (i),(iv)

C. (ii),(iii)

D. (ii),(iv)

Answer: C



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2. Which of the following expressions is not acceptable?

(i) $\Delta P = P_f - P_i$

(ii) $\Delta_w = w_f - w_i$

(iii) $\Delta q = q_f - q_i$

(iv) $\Delta U = U_f - U_i$

A. (i),(ii)

B. (ii),(iii)

C. (iii),(iv)

D. (i),(iv)

Answer: B



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3. During an adiabatic process,

A. $\Delta P = 0$

B. $\Delta V = 0$

C. $\Delta T = 0$

D. $q = 0$

Answer: D

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4. Work done during isothermal volume change (in one step) under a constant external pressure (isothermal irreversible process) is given by

A. $w = P_{ex} \Delta V$

B. $w = - P_{ex} \Delta V$

C. $w = V \Delta P_{ex}$

D. $w = - V \Delta P_{ex}$

Answer: B

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5. Work done during isothermal reversible process is given

$$\text{A. } w = \frac{RT}{n} \frac{\ln(V_f)}{V_i}$$

$$\text{B. } w = - \frac{nRT}{n} \frac{\ln(V_f)}{V_i}$$

$$\text{C. } w = - nRT \frac{\ln(V_f)}{V_i}$$

$$\text{D. } w = - nRT \frac{\ln(V_f)}{V_i}$$

Answer: C



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6. Work (w) is a path function, i.e., the amount of work done is dependent on the process. It is ___ for a reversible process.

A. zero

B. smallest

C. infinite

D. greatest

Answer: D



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7. The internal energy (U) of a thermodynamic system includes

(i) kinetic energies of the molecules

energies of attraction among subatomic particles (atoms, ions or molecules)

(iii) energies of repulsion

(iv) other forms of energy

A. (i),(ii),(iii),(iv)

B. (ii),(iii)

C. (i),(ii),(iii)

D. (iv)

Answer: A



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8. According to the first law of thermodynamics, the internal energy of a/an _____ is constant.

- A. open system
- B. isolated system
- C. closed system
- D. thermodynamic system

Answer: B



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9. Which of the following is the mathematical statement of the first law of thermodynamics?

- A. $\Delta U = q - w$
- B. $\Delta U = w - q$
- C. $\Delta U = q + w$

$$D. \Delta U = -(q + w)$$

Answer: C



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10. When no heat is absorbed by the system then from the surroundings, but work (w) is done on the system, the change in internal energy of the system is given as

A. $\Delta U = q + w$

B. $\Delta U = q - w$

C. $\Delta U = -q$

D. $\Delta U = w_{ad}$

Answer: D



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11. For an isothermal free expansion of an ideal gas,

A. $\Delta U = 0, q = 0, w = 0$

B. $\Delta U \neq 0, q \neq 0, w = 0$

C. $\Delta U \neq 0, q = 0, w = 0$

D. $\Delta U = 0, q \neq 0, w = 0$

Answer: A



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12. Which of the the following is not a pathh function?

(i) q

(ii) w

(iii) qb

(iv) $q + w$

A. (i),(ii),(iii),(iv)

B. (iii),(iv)

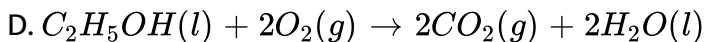
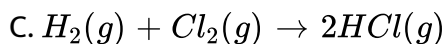
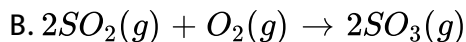
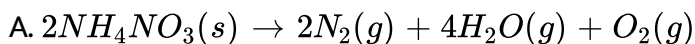
C. (i),(ii)

D. (i),(ii),(iii)

Answer: B

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13. Each of the following chemical reaction is carried out at constant temperature and constant pressure. Considering the reaction mixture to be the system, predict the reaction for which w is zero?



Answer: C

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14. Change in internal energy of a thermodynamic system is called heat of reaction at constant

- A. temperature
- B. pressure
- C. volume
- D. both (1) and (2)

Answer: C



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Follow Up Test 3

1. The fundamental definition of enthalpy is

A. $\Delta H = \Delta U + \Delta(PV)$

B. $H = U + PV$

C. $H = U - PV$

D. $\Delta H = \Delta U + P\Delta V$

Answer: B



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2. Which of the following is incorrect about enthalpy?

A. Its absolute value can be determined accurately.

B. It is a state function.

C. It is an extensive property.

D. Enthalpy change can be determined using the first law of thermodynamics.

Answer: A



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3. The heat flow under _____ conditions is a direct measurement of ΔH

- A. isochoric
- B. isothermal
- C. isobaric
- D. adiabatic

Answer: C

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4. For is process involving solids and / or liquids,

- A. $\Delta H > \Delta U$
- B. $\Delta H < \Delta U$
- C. $\Delta H = \Delta U = 0$

D. $\Delta H \cong \Delta U$

Answer: D

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5. The difference between heats of reaction at constant pressure and constant volume for a given reaction is

A. $(\Delta n_g)RT$

B. $(\Delta n_g)R/T$

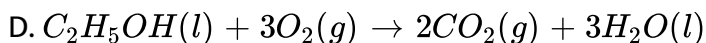
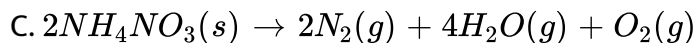
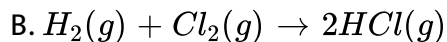
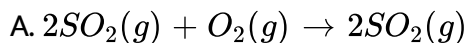
C. $(\Delta n_g)T/R$

D. $\Delta n_g RT^2$

Answer: A

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6. Which of the following reaction has $\Delta H = \Delta U$?



Answer: B



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7. Consider a gas enclosed in a container. If two divide the container into three equal parts partition, then which of each of the following properties of gas will have the same value is each of the compartment?

A. Internal energy

B. Enthalpy

C. volume

D. Temperature

Answer: D



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8. Which of the following is an exothermic reaction?

A. Conversion of graphite to diamond

B. Dehydrogenation of ethane to ethylene

C. Combustion of methane

D. Decomposition of water

Answer: C



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9. If the door of a refrigerator is kept open, then which of the following is true

A. gets heated

B. gets cooled

C. neither get cooled nor gets heated

D. gets cooled or heated depending on the initial temperature ture of the room

Answer: A



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10. Which of the following are intensive properties?

A. Volume

B. Enthalpy

C. Refractive index

D. Internal energy

Answer: C



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Follow Up Test 4

1. Which of the following is the best description of heat capacity?

A. $C = \frac{q}{\Delta T}$

B. $C = \lim_{\Delta T \rightarrow 0} \frac{q}{\Delta T}$

C. $C = \lim_{q \rightarrow 0} \frac{q}{\Delta T}$

D. $C = \frac{\Delta q}{\Delta T}$

Answer: B



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2. Which of the following is an extensive property?

- A. Heat capacity
- B. Molar heat capacity
- C. Specific heat capacity
- D. both (2) and (3)

Answer: A



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3. Specific heat capacity of water is

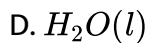
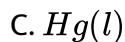
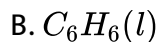
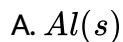
- A. $2.09 \text{ Jg}^{-1} \text{ K}^{-1}$
- B. 1 JK^{-1}
- C. $4.18 \text{ Jg}^{-1} \text{ K}^{-1}$
- D. $1.74 \text{ Jg}^{-1} \text{ K}^{-1}$

Answer: C



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4. We add the same amount of heat to ten grams of each of the following substance at $20^{\circ}C$. Which of the samples show the lowest temperature change?



Answer: D



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5. For an ideal monoatomic gas, molar heat capacity at constant volume (C_v) is

A. $\frac{2}{3}R$

B. $\frac{3}{2}R$

C. $\frac{5}{2}R$

D. $\frac{2}{5}R$

Answer: B



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6. The ratio C_P/C_V represented by γ corresponds to the atomicity of an ideal gas. Which of following ratios corresponds to a diatomic molecule such a oxygen?

A. $C_P/C_V = 1.66$

B. $C_P/C_V = 1.30$

C. $C_P/C_V = 1.40$

D. $C_P/C_V = 1.22$

Answer: C

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7. Which of the following heat change is measured with the help of bomb calorimeter?

A. Heat of neutralization

B. Heat of ionization

C. Heat of fusion

D. Heat of combustion

Answer: D

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8. The molar heat capacity of water in equilibrium with ice at constant pressure is

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

B. $40.45 JK^{-1} mol^{-1}$

C. zero

D. infinity

Answer: D



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9. $C_P - C_V$ for an ideal gas is..... .

A. R^2

B. \sqrt{R}

C. R

D. $R/2$

Answer: C

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10. Constant- volume calorimeter measures

A. ΔH

B. ΔU

C. H

D. U

Answer: B

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Follow Up Test 5

1. The enthalpy of reaction, $\Delta_1 H$, is

A. $\Delta_r = H(\text{product}) + H(\text{reactants})$

B. $\Delta_r = H(\text{reactants}) - H(\text{products})$

C. $\Delta_r = H(\text{product}) - H(\text{reactants})$

D. $\Delta_r = H(\text{reactants}) + H(\text{products})$

Answer: C

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2. Reaction enthalpy does not depend upon

A. amounts states reactions involved

B. physical states of the reactants and products

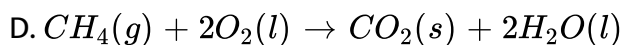
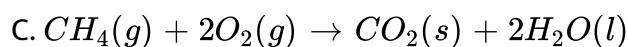
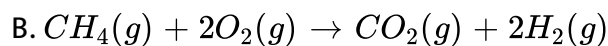
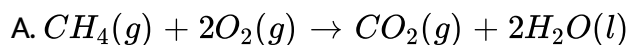
C. allotropic modifications

D. pathway of reaction

Answer: D

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3. Which of the following equations refers to standard enthalpy of reaction?



Answer: A



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4. Standard thermodynamic conditions chosen for substance when listing or comparing thermodynamic data refer to

A. one atmosphere pressure and $273K$

B. one bar pressure and any specified temperature

C. one atmosphere pressure and $298K$

D. one bar pressure and 298 K

Answer: B

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5. Which of the following describes the thermodynamic standard state of carbon?

A. Graphite

B. Diamond

C. Buckminsterfullerence

D. Charcoal

Answer: A

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6. Standard enthalpy of fusion ($\Delta_{fus}H^\circ$) is the amount of heat required to melt ____ of a solid at its melting point and at a standard pressure of 1 bar.

- A. gram
- B. kilogram
- C. mole
- D. molecule

Answer: C

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7. 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 water? If latent heat of evaporation for H_2O is $40.79kJmol^{-1}$ at $100^\circ C$.

- A. $37.56kJmol^{-1}$

B. $43.76 \text{ kJ mol}^{-1}$

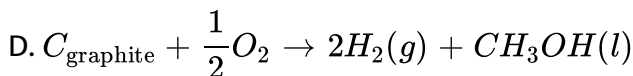
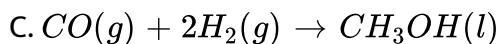
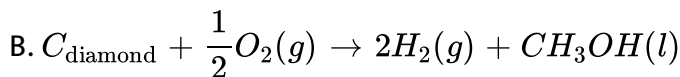
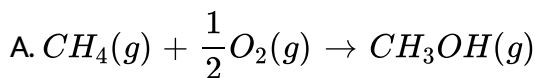
C. $49.65 \text{ kJ mol}^{-1}$

D. $32.65 \text{ kJ mol}^{-1}$

Answer: A

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8. Here, in which case can the calculated standard reaction enthalpy ($\Delta_r H^\circ$) be identified as the standard molar enthalpy of formation for methanol ($\Delta_f H_{\text{CH}_3\text{OH}}^\circ$)?

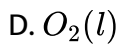
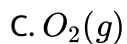
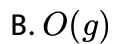
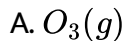


Answer: D



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9. Which of the following has zero value for $D_f H^\circ$?

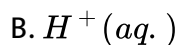
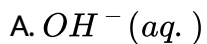


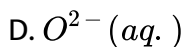
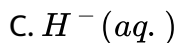
Answer: C



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10. By covention, the standard enthalpy of formation of _____ is taken as zero.





Answer: B

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11. Consider the reaction $PbO(s) + CO(g) + CO_2(g)$,

$\Delta_r H^\circ = -65.69 kJ mol^{-1}$. If $\Delta_f H^\circ$ for CO_2 and $CO(g)$ are $393.5 kJ mol^{-1}$ and $-110.5 kJ mol^{-1}$, respectively, calculate $\Delta_f H^\circ$ for yellow $PbO(s)$

A. $+217.3 kJ mol^{-1}$

B. $-317.2 kJ mol^{-1}$

C. $+317.2 kJ mol^{-1}$

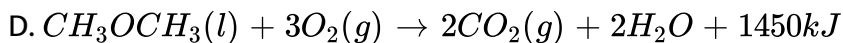
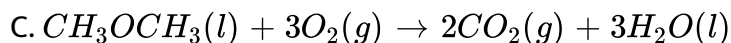
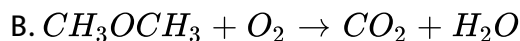
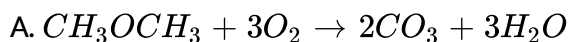
D. $-217.3 kJ mol^{-1}$

Answer: D

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Follow Up Test 6

1. Which of the following is a thermochemical equation?

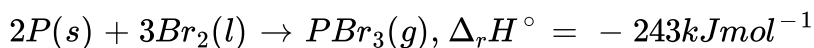


Answer: D



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2. Red phosphorus reacts with liquid bromine in an exothermic reaction



Calculated the enthalpy change when 2.63g of phosphorus reacts with an excess of bromine in this way.

A. 10.3kJ

B. 1536kJ

C. 7.5kJ

D. 20.3kJ

Answer: A



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3. Hess's law of heat summation is in agreement with

A. zeroth law of thermodynamics

B. first law of thermodynamics

C. second law of thermodynamics

D. third law of thermodynamic

Answer: B



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4. For the transition



it follows that

- A. diamond is more stable than graphite
- B. graphite is more stable than diamond
- C. both diamond and graphite are equally stable
- D. nothing can be predicted from this reaction

Answer: B



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5. Hess's law of constant heat summation is applied to calculate

- A. the enthalpy of a reaction which is not feasible
- B. the enthalpy of a reaction which does not go to completion
- C. the calorific value of a fuel
- D. All of these

Answer: D

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6. The coefficients in a balanced thermochemical equation refer to the number of _____ of reactants and products involved in the reaction.

- A. moles
- B. molecules
- C. volumes
- D. All of these

Answer: A

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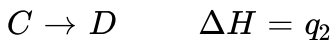
7. Hess's law of constant heat summation is consistent with the fact that enthalpy is

- A. an extensive property
- B. an intensive property
- C. a state function
- D. a path function

Answer: C

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8. A hypothetical reaction, $A \rightarrow 2B$, proceeds via following sequence of steps



The heat of reaction is

A. $q_1 + q_2 - 2q_3$

B. $q_1 + q_2 + 2q_3$

C. $q_1 + 2q_2 - 2q_3$

D. $q_1 - q_2 + 2q_3$

Answer: B



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9. Which of the following is the mathematical form of Hess's law?

A. $\Delta H_{rxn}^\circ = \sum n\Delta_f H^\circ (\text{products}) - \sum n\Delta_f H^\circ (\text{reactants})$

B. $\Delta H_{rxn}^\circ = \sum n\Delta_f H^\circ (\text{products}) / \sum n\Delta_f H^\circ (\text{reactants})$

C. $\Delta H_{rxn}^\circ = \sum n\Delta_f H^\circ (\text{products}) + \sum n\Delta_f H^\circ (\text{reactants})$

D. All of these

Answer: A

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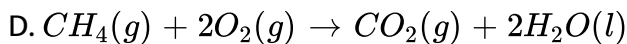
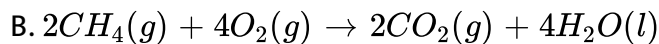
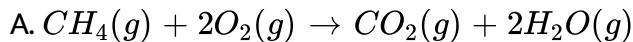
10. Which of the following information is not conveyed by a thermochemical equation?

- A. Enthalpy change of reaction
- B. physical states of the reactants and products
- C. Number of moles of reactants and products
- D. Rate of chemical reaction

Answer: D

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1. Which of the following reaction corresponds with the definition of standard enthalpy of combustion?

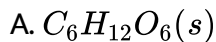


Answer: D

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2. Standard enthalpies of combustion for $H_2(g)$, $CO(g)$, $CH_4(g)$, and $C_6H_{12}O_6(s)$ are -258 , -283 , -890 , and $-2802 \text{ kJ mol}^{-1}$, respectively.

Which of the following has minimum calorific value?



C. $CO(g)$

D. $H_2(g)$

Answer: C



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3. Enthalpy of combustion ($\Delta_c H$) depends on

- (i) whether combustion is carried out in constant volume calorimeter or constant pressure calorimeter
- (ii) the physical state of the substances
- (iii) the temperature at which combustion is carried out
- (iv) the amount of oxygen present

A. (i),(ii),(iii)

B. (i),(ii),(iii),(iv)

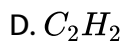
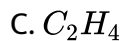
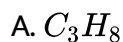
C. (iii),(iv)

D. (i),(ii)

Answer: A

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4. Which of the following has maximum standard enthalpy of combustion per gram?



Answer: B

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5. Which of the following is incorrect?

- A. Calorific value of fat is more than that of carbohydrate and protein.
- B. $\Delta_C H^\circ$ is always negative
- C. Calorific value of kerosene is less than that of coal.
- D. Butane is the main component of cooking gas.

Answer: C

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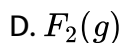
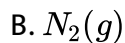
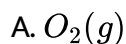
6. Which of following equations does not correspond to the standard enthalpy of atomization?

- A. $H_2(g) \rightarrow 2H(g)$
- B. $CH_4(g) \rightarrow C(g) + 4H(g)$
- C. $Na(s) \rightarrow Na(g)$
- D. $Br_2(g) \rightarrow 2Br(g)$

Answer: D

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7. Bond dissociation enthalpy and bond enthalpy are not the same for



Answer: C

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8. In the dissociation of CH_4 , minimum energy is required in the _____ step.

A. fourth

B. third

C. second

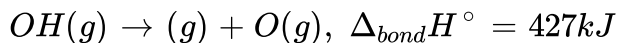
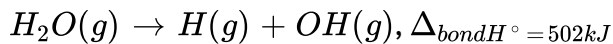
D. first

Answer: A



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9. Calculate the bond enthalpy of the $O - H$ bond using the following thermochemical equations:



A. $502kJ$

B. $464.5kJ$

C. $427kJ$

D. $929kJ$

Answer: B



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Follow Up Test 8

1. Enthalpy of solution ($\Delta_{Sol}H^\circ$) of a solute is the enthalpy change when one mole of it dissolves in _____ of solvent

- A. excess
- B. an unknown amount
- C. a specified amount
- D. an infinite amount

Answer: C



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2. Which of the following interactions operate during to process of solvation?

- A. Solvent - solute
- B. Solvent - solvent
- C. Solute-solute
- D. All of these

Answer: A

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3. Lattice enthalpy is the enthalpy change for completely separating one mole of a solid ionic compound into its constituent ions in the _____phase.

- A. solid
- B. gas
- C. liquid
- D. solution

Answer: B

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4. Which of the following ionic solids tend to be the least soluble in water?

A. Iodides

B. Bromides

C. Chlorides

D. Fluorides

Answer: D

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5. How many steps are involved in the Born-Harber cycle for sodium chloride?

A. Four

B. Five

C. Six

D. Seven

Answer: B

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6. Which of the following measures the stability of an ionic solid?

A. Lattice enthalpy

B. Hydration enthalpy

C. Enthalpy of solution

D. All of these

Answer: A

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7. The Born-Haber cycle is used to determine

- A. ionization enthalpy
- B. electron gain enthalpy
- C. lattice enthalpy
- D. bond enthalpy

Answer: C



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Follow Up Test 9

1. Which of the following facts cannot be answered by the first law of thermodynamics?

- A. During a spontaneous process, energy of the universe is constant

- B. During a nonspontaneous process, energy of the universe is constant
- C. Transformation take place spontaneously in one direction but not in the other.
- D. All of these

Answer: C

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2. Which of the following is correct for a spontaneous process?

- A. All spontaneous changes proceed very fast/
- B. All spontaneous changes proceed till equilibrium is achieved.
- C. All spontaneous changes are exothermic:
- D. All of these

Answer: B



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3. Expansion of an ideal gas through a pinhole into vacuum is a spontaneous process. In this expansion, there is _____ of the system.

- A. large energy change
- B. small energy change
- C. very large energy change
- D. no energy change

Answer: D



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4. Which of the following is incorrect about entropy (S)?

- A. It is a thermodynamic property
- B. It is a direct measure of the randomness or disorder of a system

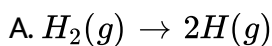
C. It is an intensive property.

D. It is a state function.

Answer: C

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5. Which of the following process is associated with a decrease in entropy?



C. Temperature of a crystalline solid is raised from $0K$ to $115K$

D. A liquid crystallizer into a solid.

Answer: D

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6. $\Delta S = \Delta H/T$ holds good for

- A. a process under any condition
- B. an isothermal reversible phase change
- C. an adiabatic process
- D. a process at constant pressure

Answer: B



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7. Second law of thermodynamics states that in spontaneous changes, the _____ tends towards a state of greater disorder.

- A. universe
- B. system
- C. surroundings
- D. system or surroundings

Answer: A

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8. For an irreversible process,

A. $\Delta S_{sys} + \Delta S_{surr} = 0$

B. $\Delta S_{sys} + \Delta S_{surr} < 0$

C. $\Delta S_{sys} + \Delta S_{surr} > 0$

D. $\Delta S_{sys} = \Delta S_{surr}$

Answer: C

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9. Which of the following permits the calculation of absolute values of entropy of a pure substance from thermal data alone?

A. Second law of thermodynamics

B. Third law of thermodynamics

C. First law of thermodynamics

D. Zeroth of thermodynamics

Answer: B

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10. If n moles of an ideal gas are expanded isothermally and reversibly from an initial state in which it has pressure p_1 and volume V_1 to the final state of volume V_2 and pressure P_2 , then

A. $\Delta S_{sys} = -2.303nR \log\left(\frac{P_1}{p_2}\right)$

B. $\Delta S_{sys} = 2.303\frac{R}{n} \log\left(\frac{P_1}{p_2}\right)$

C. $\Delta S_{sys} = -2.303\frac{R}{n} \log\left(\frac{P_1}{p_2}\right)$

D. $\Delta S_{sys} = 2.303nR \log\left(\frac{P_1}{p_2}\right)$

Answer: D

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Follow Up Test 10

1. Gibbs energy of Gibbs function, G , is defined as

A. $G = U + TS$

B. $G = H - TS$

C. $G = H + TS$

D. $G = U - TS$

Answer: B

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2. The changes in gibbs energy (ΔG) of a system for a process at constant temperature and pressure is

A. $\Delta G = \Delta H / TS$

B. $\Delta G = T\Delta S / \Delta H$

C. $\Delta G = \Delta H - T\Delta S$

D. $\Delta G = \Delta S - T\Delta H$

Answer: C

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3. Which of the following relationships is a useful manifestation of the second law?

A. $\Delta G_{\text{sys}} = -T\Delta S_{\text{univ}}$

B. $\Delta G_{\text{sys}} = T\Delta S_{\text{univ}}$

C. $\Delta G_{\text{sys}} = \frac{\Delta S_{\text{univ}}}{T}$

$$D. \Delta G_{\text{sys}} = \frac{-\Delta S_{\text{univ}}}{T}$$

Answer: A

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4. All natural processes proceed spontaneously in a direction which

- A. reduces free energy to zero
- B. increase free energy
- C. decrease entropy
- D. decreases gibbs free energy

Answer: D

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5. The standard Gibbs energy of formation is nonzero for

A. C (graphite)

B. $O_2(g)$

C. $O_3(g)$

D. S (rhombic)

Answer: C

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6. Which of the following conditions leads to a spontaneous process at all temperature

A. ΔH is positive and ΔS is negative

B. ΔH is negative and ΔS is positive.

C. Both ΔH and ΔS are negative.

D. Both ΔH and ΔS are positive

Answer: B

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7. Which of the following expression defines the physical significance of Gibbs energy change

A. $\Delta G = W(\text{exp})$

B. $\Delta(G) = W(\text{nonexp})$

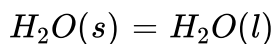
C. $\Delta G = -W(\text{exp})$

D. $-\Delta G = W(\text{nonexp})$

Answer: D

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8. Which of the following is true for the process



at $0^\circ C$ and 1 atm?

A. $\Delta H = 0$

B. $\Delta S = \Delta H / T$

C. $\Delta S = 0$

D. $\Delta H = \Delta U$

Answer: B

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9. The equilibrium constant of a reaction and the standard Gibbs energy change of the reaction are related by the equation

A. $\Delta G^\circ = -RT \ln K$

B. $\Delta G^\circ = RT \ln K$

C. $\Delta G^\circ = nRT \ln K$

D. $\Delta G^\circ = -nRT \ln K$

Answer: B

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10. Which of the equilibrium constant is measured through the value of ΔG° ?

- A. Very large K
- B. Very small K
- C. Both (1) and (2)
- D. $K = 1$

Answer: C

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Question Bank Level I

1. Under which of the following condition is the relation $\Delta H = \Delta U + P\Delta V$ valid for a closed system at

A. Constant temperature, pressure, and composition

B. Constant temperature and pressure

C. Constant pressure

D. Constant temperature

Answer: C



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2. Which of the following is included in thermodynamic equilibrium?

A. Thermal equilibrium

B. Chemical equilibrium

C. Pressure equilibrium

D. All of these

Answer: D



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3. If one mole of ammonia and one mole of hydrogen chloride are mixed in a closed container to form ammonium chloride vapor, then

A. $\Delta H = \Delta U$

B. $\Delta H > \Delta U$

C. $\Delta H < \Delta U$

D. there is no relationship

Answer: C



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4. In thermodynamics, a process is called reversible when

A. the system changes into the surrounding spontaneously

B. the surrounding are always in equilibrium with the system

C. there is no boundary between and surrounding

D. surroundings and system change into each other

Answer: B



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5. If $K < 1$ then the value of ΔG° will be

A. positive

B. negative

C. zero

D. 1

Answer: A



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6. When a solid melts reversibly

A. G increases

B. H decreases

C. E decreases

D. S increases

Answer: D



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7. Identify the extensive quantities from the following

(i) refractive

(ii) volume

(iii) temperature

(iv) enthalpy

A. (i),(ii),(iii),(iv)

B. (i),(iii)

C. (ii),(iv)

D. (i),(iv)

Answer: C



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8. The heat required to raise the temperature of a body of $1K$ is called

- A. water equivalent
- B. specific heat
- C. thermal (or heat capacity)
- D. molar heat capacity

Answer: C



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1. A piston filled with 0.04 mole of an ideal gas expands reversibly from 50.0 mL at a constant temperature of 37.0°C . As it does so, it absorbs 208 J of heat. The value of q and W for the process will be ($R = 8.314\text{J/molK}$, $\ln 7.5 = 2.01$)

A. $q = + 208\text{J}$, $w = - 208\text{J}$

B. $q = + 208\text{J}$, $w = + 208\text{J}$

C. $q = - 208\text{J}$, $w = + 208\text{J}$

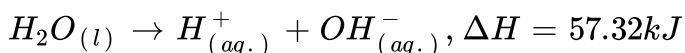
D. $q = - 208\text{J}$, $w = - 208\text{J}$

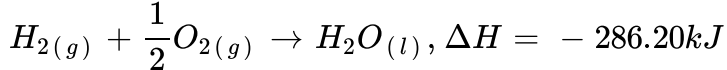
Answer: A

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2. On the basis of the following thermochemical data :

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





The value of enthalpy of formation of OH^- ion at $25^\circ C$ is :

A. $-228.88kJ$

B. $+228.88kJ$

C. $-22.88kJ$

D. $-343.52kJ$

Answer: A



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3. If an exothermic reaction occurs spontaneously at constant temperature and pressure, then which of the following is true?

A. $\Delta S < 0$

B. $\Delta S > 0$

C. $\Delta H < 0$

D. $\Delta G > 0$

Answer: B

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4. For the process $H_2O(l)(1\text{bar}, 373\text{K}) \rightarrow H_2O(g)(1\text{bar}, 373\text{K})$ the correct set of thermodynamic parameters is

A. $\Delta G = -ve, \Delta S = +ve$

B. $\Delta G = +ve, \Delta S = 0$

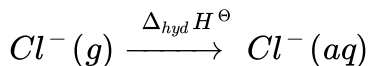
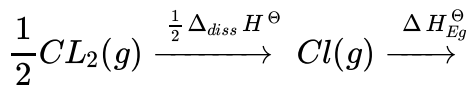
C. $\Delta G = 0, \Delta S = +ve$

D. $\Delta G = 0, \Delta S = -ve$

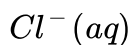
Answer: C

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5. Oxidising power of chlorine in aqueous solution can be determined by the parameters indicated below



The energy involved in the conversion of $\frac{1}{2}Cl_2(g)$ to



(Using the data $\Delta_{diss} H_{Cl_2}^\ominus = 240 \text{ kJ mol}^{-1}$)

$$\Delta_{Eg} H_{Cl}^\ominus = -349 \text{ kJ mol}^{-1},$$

$$\Delta_{Eg} H_{Cl}^\ominus = -381 \text{ kJ mol}^{-1}) \text{ will be}$$

A. -610 kJ mol^{-1}

B. $+150 \text{ kJ mol}^{-1}$

C. $+120 \text{ kJ mol}^{-1}$

D. -850 kJ mol^{-1}

Answer: A



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6. For an ideal gas expanding adiabatically in vacuum,

A. $\Delta H < 0$

B. $\Delta H = 0$

C. $\Delta H > 0$

D. none of these

Answer: B



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7. ΔG° for a reaction is $46.06 \text{ kcal mol}^{-1}$. K_P for the reaction at 300K is

A. $10^{-22.22}$

B. 10^{-8}

C. $10^{-44.55}$

D. $10^{-35.54}$

Answer: D

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8. Assuming that water vapour is an ideal gas, the internal energy change (ΔU) when 1 mole of water is vaporised at 1bar pressure and 100°C , (given: molar enthalpy of vaporization of water 41kJmol^{-1} at 1bar and 373K and $R = 8.3\text{Jmol}^{-1}\text{K}^{-1}$) will be :

A. 3.7904kJmol^{-1}

B. 41kJmol^{-1}

C. 37.904kJmol^{-1}

D. 4.1kJmol^{-1}

Answer: C

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9. Identify the correct statement regarding a spontaneous process :

A. Exothermic reaction are always spontaneous.

B. Endothermic reaction are never spontaneous.

C. Lowering of energy in the reaction of physical process is the only criterion for spontaneity

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

Answer: D



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10. Which of the following statement is true?

Work appears at the boundary of the system.

(ii) Change in the state is completely defined when the initial and final states are specified.

(iii) Temperature is a state function.

(iv) Work is a state function.

A. (i),(ii),(iii)

B. (i),(ii),(iii),(iv)

C. (ii),(iii),(iv)

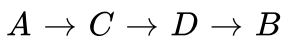
D. (ii),(iii)

Answer: A



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11. The direct conversion of A to B is difficult, hence it is carried out as



Given, $\Delta S_{(A \rightarrow C)} = 50eU$, $\Delta S_{(C \rightarrow D)} = 30eU$, $\Delta S_{(B \rightarrow D)} = 20eU$,

where eU is entropy unit. Thus the change in entropy in $(A \rightarrow B)$ is:

A. $-100eu$

B. $-60eu$

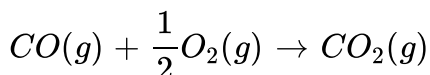
C. +60eu

D. +100eu

Answer: C

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12. For the reaction



ΔH and ΔS are $283kJ$ and $-87JK^{-1}$, respectively. It was intended to carry out this reaction at 1000,1500,3000, and 3500 K. At which of these temperatures would this reaction be thermodynamically spontaneous?

A. 3000 and 3500 K

B. 1500 and 3000 K

C. 1500 , 3000, and 3500 K

D. 1000, 1500, and 3000 K

Answer: D



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13. Which of the following equations does not correctly represent the first law of thermodynamics?

A. Expansion of a gas into vacuum : $\Delta U = q$

B. Adiabatic process : $\Delta U = -w$

C. Isochoric process : $\Delta U = q$

D. Isothermal process : $q = -w$

Answer: B



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14. The internal energy change when a system goes from state A to B is 40 kJ mol^{-1} . If the system goes from A to B by a reversible path and returns to state A by an irreversible path, what would be the net change in internal energy?

A. zero

B. $40kJ$

C. $> 40kJ$

D. $< 40kJ$

Answer: A



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Question Bank Level Iii

1. The standard enthalpies of formation of $CO_2(g)$, $H_2O(l)$, and glucose (s) at $25^\circ C$ are $-400kJmol^{-1}$, $-300kJmol^{-1}$, and $-1300kJmol^{-1}$, respectively. The standard enthalpy of combustion per gram of glucose at $25^\circ C$ is

A. $+16.11kJ$

B. $-16.11kJ$

C. $+2900\text{kJ}$

D. -2900kJ

Answer: B



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2. The second law of thermodynamic states that in a cyclic process,

A. heat cannot be converted into work

B. heat cannot be converted completely into work

C. work cannot be converted completely into heat

D. work cannot be converted into heat

Answer: B



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3. In a constant volume calorimeter, 3.5g of a gas with molecular weight 28 was burnt in excess oxygen at 298.0K. The temperature of the calorimeter was found to increase from 298.0K \rightarrow 298.45K due to the combustion process. Given that the heat capacity of the calorimeter is 2.5kJK^{-1} , find the numerical value for the enthalpy of combustion of the gas in kJmol^{-1}

A. 8

B. 7

C. 9

D. 6

Answer: C



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4. The enthalpy changes state for the following processes are listed below:

$$Cl_2(g) = 2Cl(g) : 242.3KJmol^{-1}$$

$$I_2(g) = 2I(g) , 151.0KJmol^{-1}$$

$$ICl(g) = I(g) + Cl(g) : 211.3KJmol^{-1}$$

$$I_2(s) = I_2(g) , 62.76KJmol^{-1}$$

Given that the standard states for iodine chlorine are $I_2(s)$ and $Cl_2(g)$,
the standard enthalpy of formation for $ICl(g)$ is:

A. $33.5kJmol^{-1}$

B. $16.8kJmol^{-1}$

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

D. $-211.3kJmol^{-1}$

Answer: B



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5. How many calories are required to heat 40g of argon from $40^{\circ}C$ to $100^{\circ}C$ at constant volume? ($R = 2calmol^{-1}K^{-1}$)

A. 1200

B. 120

C. 180

D. 2400

Answer: C



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6. Which one of the following sets of units represents the smallest and the largest amount of energy, respectively?

A. L atm and J

B. eV and L atm

C. cal and eV

D. erg and cal

Answer: B

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7. 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 $25^\circ C$ in kJ is

A. + 7.43

B. - 3.72

C. - 7.43

D. + 3.72

Answer: C

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8. Water is supercooled to $-4^\circ C$. The enthalpy (H) is

A. more than ice at $-4^\circ C$

B. less than ice at $-4^{\circ}C$

C. same as ice at $-4^{\circ}C$

D. same as ice at $0^{\circ}C$

Answer: A



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9. The enthalpy of certain reaction at $273K$ is $-20.75kJ$. The enthalpy of the same reaction at $373K$ provided heat capacities for reactants and products are the same) will be

A. $-2075kJ$

B. zero

C. $20.75 \times \frac{373}{273} kJ$

D. $-20.75kJ$

Answer: D



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10. Two moles of an ideal gas expanded isothermally and reversibly from $1L$ to $10L$ at $300K$. What is the enthalpy change?

A. $-11.47kJ$

B. $11.47kJ$

C. $0kJ$

D. $4.98kJ$

Answer: C



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11. In an irreversible process taking place at constant T and P and in which only pressure-volume work is being done, the change in Gibbs free energy (dG) and the change in entropy (dS) satisfy the criteria

A. $(dS)_{V,E} < 0, (dG)_{T,P} < 0$

B. $(dS)_{V,E} = 0, (dG)_{T,P} > 0$

C. $(dS)_{V,E} = 0, (dG)_{T,P} = 0$

D. $(dS)_{V,E} > 0, (dG)_{T,P} < 0$

Answer: D

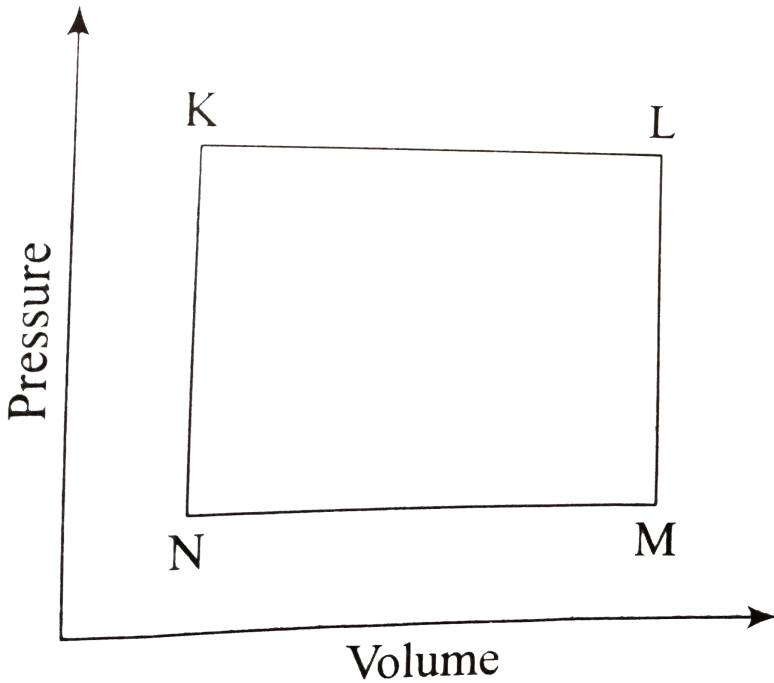


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Question Bank Level Iv

1. A fixed mass m of a gas is subjected to transformation of state: K to L to M and back to K as shown in the figure.

The succeeding operations that enable this transformation of state are



- A. cooling, heating, heating, cooling
- B. cooling, heating, cooling, heating
- C. heating, cooling, heating, cooling
- D. heating, cooling, cooling, heating

Answer: D



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2. The value of $\log_{10} K$ for a reaction $A \rightleftharpoons B$ is (Given:

$$\Delta_f H_{298K}^\ominus = -54.07 \text{ kJ mol}^{-1},$$

$$\Delta_r S_{298K}^\ominus = 10 \text{ JK}^{-1} \text{ mol}^{-1}, \text{ and } R = 8.314 \text{ JK}^{-1} \text{ mol}^{-1}$$

A. 100

B. 95

C. 5

D. 10

Answer: D



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3. Which of the following does not express the criterion of spontaneity?

A. $(dS)_{P,T} > 0$

B. $(dA)_{V,T} > 0$

C. $(dS)_{P,T} > 0$

D. All of these

Answer: B

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4. A process is nonspontaneous at every temperature if

(i) $\Delta H > 0, \Delta S = 0$

(ii) $\Delta H < 0, \Delta S > 0$

(iii) $\Delta H > 0, \Delta S < 0$

(iv) $\Delta H = 0, \Delta S < 0$

A. (i),(ii),(iii)

B. (ii),(iii),(iv)

C. (i),(ii),(iii),(iv)

D. (i),(iii),(iv)

Answer: D

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5. When 0.1 mol of a gas absorbs 41.75J of heat at constant volume, the rise in temperature occurs equal to $20^{\circ}C$. The gas must be

- A. monoatomic
- B. diatomic
- C. triatomic
- D. polyatomic

Answer: B



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6. One mole of a non-ideal gas undergoes a change of state $(2.0\text{atm}, 3.0L, 95K) \rightarrow (4.0\text{atm}, 5.0L, 245K)$

With a change in internal energy $\Delta E = 30L \text{ atm}$. The change in enthalpy (ΔH) in the process in $L\text{-atm}$ is

A. 42.3

B. 40

C. 44

D. not defined, because

Answer: C

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Archives

1. The values of ΔH and ΔS for the reaction are 170kJ and 170JK^{-1} , respectively. This reaction will be spontaneous at

A. 910K

B. 1110K

C. 510K

D. 710K

Answer: B

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2. Which of the ions in the table below would have the largest value of enthalpy of hydration?

Ionic radius in nm Charge of ion

A. 0.0065 + 2

B. 0.095 +1

C. 0.135 +2

D. 0.181 +1

Answer: A

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3. Change in internal energy when $4kJ$ of work is done on the system and $1kJ$ of heat is given out of the system is

A. $+1kJ$

B. $-5kJ$

C. $+5kJ$

D. $+3kJ$

Answer: D



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4. $4.48L$ of an ideal gas at STP requires 12 cal to raise its temperature by $15^\circ C$ at constant volume. The C_P of the gas is

A. 3 cal

B. 4 cal

C. 7 cal

D. 6 cal

Answer: D

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5. Standard entropy of X_2 , Y_2 and XY_3 are 60 , 40 and $50JK^{-1}mol^{-1}$, respectively. For the reaction, $\frac{1}{2}X_2 + \frac{3}{2}Y_2 \rightarrow XY_3$, $\Delta H = -30KJ$, to be at equilibrium, the temperature will be:

A. $750K$

B. $1000K$

C. $1250K$

D. $500K$

Answer: A

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6. Bond dissociation enthalpy of H_2 , Cl_2 and HCl are 434, 242 and 431 kJ mol^{-1} respectively. Enthalpy of formation of HCl is

A. 93 kJ mol^{-1}

B. -245 kJ mol^{-1}

C. -93 kJ mol^{-1}

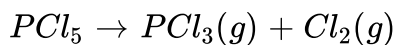
D. 245 kJ mol^{-1}

Answer: C



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7. For the gas phase reaction



which of the following conditions are correct?

A. $\Delta H = <$ and $\Delta S < 0$

B. $\Delta H > 0$ and $\Delta S > 0$

C. $\Delta H < 0$ and $\Delta S < 0$

D. $\Delta H > 0$ and $\Delta S < 0$

Answer: B



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8. Which of the following are not state functions?

(I) $q + w$

(II) q

(III) w

(IV) $H - TS$

A. (i) and (iv)

B. (ii),(iii),(iv)

C. (i),(ii),(iii)

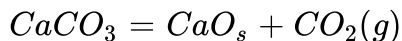
D. (ii) and (iii)

Answer: D



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9. The decomposition of limestone



is nonspontaneous at 176kJ and 160Jk^{-1} , respectively. At what temperature, the decomposition becomes spontaneous?

- A. At 10000K
- B. Below 500°C
- C. At 500°C
- D. Above 827°C

Answer:



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10. Given the bond energies of $H - H$ and $Cl - Cl$ are 430kJmol^{-1} and 240kJmol^{-1} , respectively, and $\Delta_f H^\circ$ for HCl is -90kJmol^{-1} . Bond

enthalpy of HCl is

A. $245kJmol^{-1}$

B. $290kJmol^{-1}$

C. $380kJmol^{-1}$

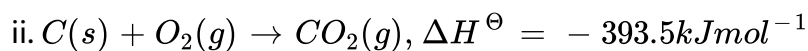
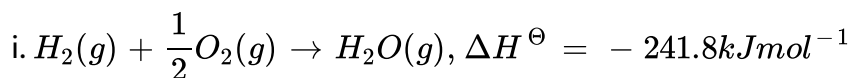
D. $425kJmol^{-1}$

Answer: D

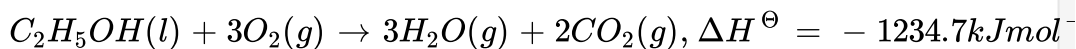


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11. Calculate the enthalpy of formation of $\Delta_f H$ for C_2H_5OH from tabulated data and its heat of combustion as represented by the following equations:



iii.



a. $-2747.1 \text{ kJ mol}^{-1}$ b. $-277.7 \text{ kJ mol}^{-1}$

c. $277.7 \text{ kJ mol}^{-1}$ d. $2747.1 \text{ kJ mol}^{-1}$

A. $+x_1 \text{ kJ mol}^{-1}$

B. $-x_2 \text{ kJ mol}^{-1}$

C. $+x_3 \text{ kJ mol}^{-1}$

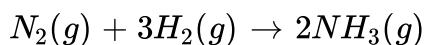
D. $x_4 \text{ kJ mol}^{-1}$

Answer: B



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12. The enthalpy change (ΔH) for the reaction



is -92.38 kJ at 298 K . The internal energy change ΔU at 298 K is

A. $-92.38 \text{ kJ mol}^{-1}$

B. -87.42 kJ

C. -97.34 kJ

D. -89.9kJ

Answer: B

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

A. -269.9kJmol^{-1}

B. -358.5kJmol^{-1}

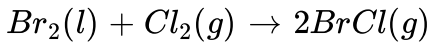
C. -508.9kJmol^{-1}

D. -208.1kJmol^{-1}

Answer: D

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14. The enthalpy and entropy change for the reaction,



are 30KJmol^{-1} and $105\text{JK}^{-1}\text{mol}^{-1}$ respectively. The temperature at which the reaction will be in equilibrium is:

- A. 450K
- B. 300K
- C. 285.7K
- D. 273K

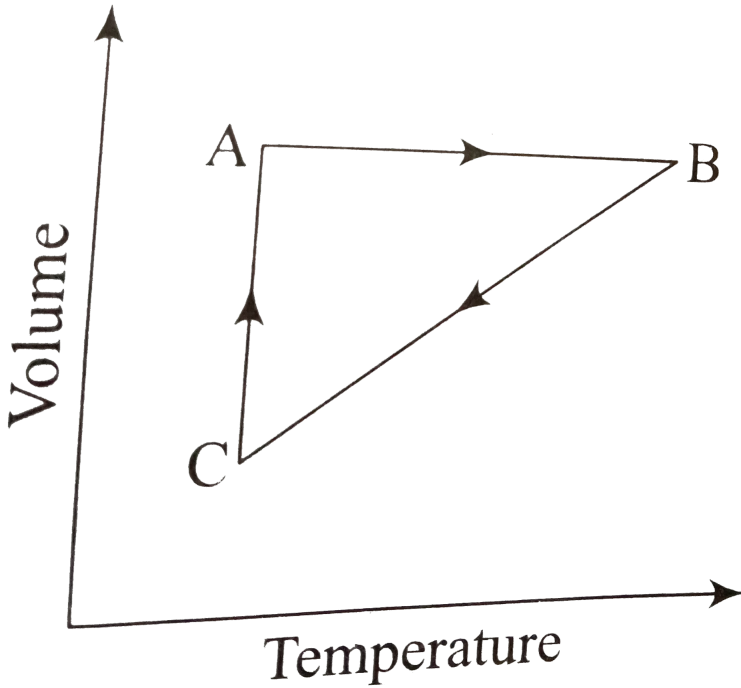
Answer: C



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15. Five mole of a gas put through a series of change as shown below graphically in a cyclic process. The processes $A \rightarrow B$, $B \rightarrow C$ and

$C \rightarrow A$, respectively, are



- A. isochoric, isobaric, isothermal
- B. isobaric, isochoric, isothermal
- C. isothermal, isobaric, isochoric
- D. isobaric, isothermal, isobaric

Answer: A



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16. The heats of neutralization of HCl with NH_4OH and $NaOH$ with CH_3COOH are $-51.4kJeq^{-1}$ and $-50.6kJeq^{-1}$, respectively. The heat of neutralization of acetic acid with NH_4OH will be

A. $-44.6kJeq^{-1}$

B. $-50.6kJeq^{-1}$

C. $-51.4kJeq^{-1}$

D. $-57.4kJeq^{-1}$

Answer: A

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17. If the heat of neutralization for a strong acid - base reaction is $-57.1kJ$, what would be the heat released when $350cm^3$ of $0.20MH_2SO_4$ is mixed with $650cm^3$ of $0.10MNaOH$?

A. $37.1kJ$

B. 3.71kJ

C. 3.17kJ

D. 0.317kJ

Answer: B

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18. Which of the following is not correct?

A. Dissolution of NH_4Cl in excess of water is an endothermic process.

B. Neutralization is always exothermic.

C. The absolute value of enthalpy (H) can be determined experimentally.

D. The heat of reaction at constant volume is denoted by ΔU

Answer: C

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19. The absolute enthalpy of neutralization of the reaction,

$MgO(s) + 2HCl(aq.) + H_2O(l)$ will be

- A. less than $-57.33kJmol^{-1}$
- B. $-57.33kJmol^{-1}$
- C. greater than $-57.33kJmol^{-1}$
- D. $57.33kJmol^{-1}$

Answer: C



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20. A reaction occurs spontaneously if:

- A. $T\Delta S < \Delta H$ and both ΔH and ΔS are $+ve$
- B. $T\Delta S > \Delta H$ and both ΔH and ΔS are $+ve$
- C. $T\Delta S = \Delta H$ and both ΔH and ΔS is $+ve$

D. $T\Delta S < \Delta H$ and ΔH is $+ve$ and ΔS is $-ve$

Answer: B

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21. The standard molar heats of formation of ethane, carbon dioxide, and liquid water are -21.1 , -94.1 , and $-68.3kcal$, respectively. Calculate the standard molar heat of combustion of ethane.

A. $372kcal$

B. $162kcal$

C. $340kcal$

D. $183.5kcal$

Answer: A

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22. For the reaction of one mole of zinc dust with one mole of sulphuric acid in a bomb calorimeter ΔU and w correspond to

A. $\Delta U < 0, w = 0$

B. $\Delta U < 0, w < 0$

C. $\Delta U > 0, w = 0$

D. $\Delta U > 0, w > 0$

Answer: A



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23. The value of ΔH and ΔS for five different reaction are given below.

Reaction	$\Delta H(kJmol^{-1})$	$\Delta S(JK^{-1}mol^{-1})$
I	+98.0	+14.8
II	+55.5	+14.8
III	+28.3	-84.8
IV	-40.5	+24.6
V	+34.7	0.0

On the basis of these values, predict which one of these will be spontaneous at all temperature?

A. Reaction I

B. Reaction II

C. Reaction III

D. Reaction IV

Answer: D



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24. A cylinder of gas supplied by Bharat Petroleum is assumed to contain 14kg of butane. If a normal family requires $20,000\text{ kJ}$ of energy per day for cooking, butane gas in the cylinder lasts

$(\Delta_C H^\circ \text{ of } C_4H_{10} = -2658\text{kJmol}^{-1})$

A. 20

B. 50

C. 40

D. 32

Answer: D

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25. One mole of a perfect gas expands isothermally to ten times its original volume. The change in entropy is

A. $0.1R$

B. $2.303R$

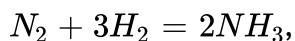
C. $10.0R$

D. $100.0R$

Answer: B

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26. For the reaction



A. $\Delta U + 2RT$

B. $\Delta U - 2RT$

C. $\Delta U + RT$

D. $\Delta U - RT$

Answer: B



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27. In a reversible process,

$\Delta S_{sys} + \Delta S_{surr}$ is

A. > 0

B. < 0

C. ≥ 0

D. $= 0$

Answer: D

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28. 1 mol of H_2SO_4 is mixed with 2 mol of $NaOH$. The heat evolved will be

A. $57.3kJ$

B. $2 \times 57.3kJ$

C. $57.3/2kJ$

D. cannot be predicted

Answer: B

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29. If the enthalpy of vaporization of benzene is $\frac{308}{k} Jmol^{-1}$ at boiling point ($80^\circ C$), calculate the entropy ($Jmol^{-1}K^{-1}$) in changing it from liquid to vapor.

A. 308

B. 0.873

C. 0.308

D. 873

Answer: D



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30. Internal energy is

A. partly potential and partly kinetic

B. totally kinetic

C. totally potential

D. none of these

Answer: A



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31. For the equilibrium



at 1 atm 298K

- A. standard free energy change is equal to zero ($\Delta G^\circ = 0$)
- B. free energy change is less than zero ($\Delta G < 0$)
- C. standard free energy change is less than zero ($\Delta G^\circ < 0$)
- D. standard free energy change is more than zero ($\Delta G^\circ > 0$)

Answer: A



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32. How much energy is released when 6 mole of octane is burnt in air ?

Given ΔH_f° for $CO_2(g)$, $H_2O(g)$ and $C_8H_{18}(l)$ respectively are

-490 , -240 and $+160KJ/mol$

A. $-6.2MJ$

B. $-37.4MJ$

C. $-35.5MJ$

D. $-20MJ$

Answer: B



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33. The work done during the expansion of a gas from a volume of $4dm^3$ to $6dm^3$ against a constant external pressure of 3 atm is (1 L atm = 101.32 J)

A. $-6J$

B. $-608J$

C. $+304J$

D. $-304J$

Answer: B

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34. The bond energies of $H - H$, $Br - Br$ and $H - Br$ are 433, 192 and 364 KJ mol^{-1} respectively. The ΔH° for the reaction $H_2(g) + Br_2(g) \rightarrow 2HBr(g)$ is

A. -261 kJ

B. $+103 \text{ kJ}$

C. $+261 \text{ kJ}$

D. -103 kJ

Answer: D

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35. Standard enthalpy and standard entropy change for the oxidation of NH_3 at $298K$ are $-382.64KJmol^{-1}$ and $145.6Jmol^{-1}$ respectively.

Standard free energy change for the same reaction at $298K$ is

A. $-523.2kJmol^{-1}$

B. $-221.1kJmol^{-1}$

C. $-339.3kJmol^{-1}$

D. $-439.3kJmol^{-1}$

Answer: C



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36. Considering entropy (S) as a thermodynamic parameter, the criterion for the spontaneity of any process is

A. $\Delta S_{\text{surroundings}} > 0$ only

B. $\Delta S_{\text{system}} + \Delta S_{\text{surroundings}} > 0$

C. $\Delta S_{\text{system}} + \Delta S_{\text{surrounding}} < 0$

D. $\Delta S_{\text{system}} > 0$ only

Answer: B

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37. The densities of graphite and diamond at $298K$ are 2.25 and $3.31gcm^{-3}$, respectively. If the standard free energy difference (ΔG^0) is equal to $1895Jmol^{-1}$, the pressure at which graphite will be transformed into diamond at $298K$ is

A. $9.92 \times 10^8 Pa$

B. $9.92 \times 10^7 Pa$

C. $9.92 \times 10^6 Pa$

D. $9.92 \times 10^5 Pa$

Answer: D

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38. What is the entropy change (in $JK^{-1}mol^{-1}$) when one mole of ice is converted into water at $0^{\circ}C$?

(The enthalpy change for the conversion of ice to liquid water is $6.0KJmol^{-1}$ at $0^{\circ}C$)

A. 20.13

B. 2.013

C. 2.198

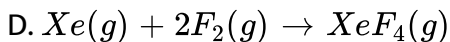
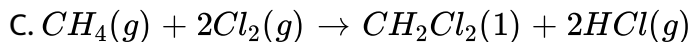
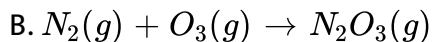
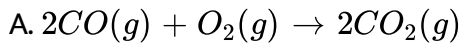
D. 21.98

Answer: D



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39. For which one of the following equations is $\Delta_r H^{\circ}$ equal to $\Delta_f H^{\circ}$ for the products (s)?



Answer: D

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40. The molar heat capacity of water at constant pressure P , is $75JK^{-1}mol^{-1}$. When $1.0KJ$ of heat is supplied to $100g$ of water which is free to expand, the increase in temperature of water is

A. $6.6K$

B. $1.2K$

C. $2.4K$

D. $4.8K$

Answer: C

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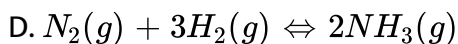
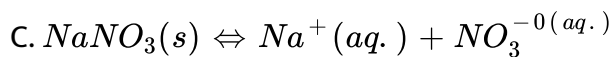
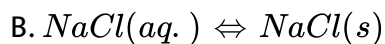
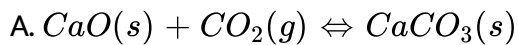
41. The system in which there is no exchange of matter, work, or energy from the surroundings is

- A. closed
- B. isolated
- C. adiabatic
- D. isothermal

Answer: B

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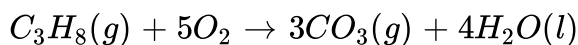
42. Which of the following has ΔS° greater than zero



Answer: C

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43. For the reaction



at constant temperature, $\Delta H - \Delta U$ is

A. $+RT$

B. $-3RT$

C. $+3RT$

D. $-RT$

Answer: B



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44. $\Delta_f H$ of graphite is 0.23 kJ mol^{-1} and $\Delta_f H$ of diamond is $1.896 \text{ kJ mol}^{-1}$. $\Delta H_{\text{transition}}$ from graphite to diamond is

A. 1.66 kJ mol^{-1}

B. 2.1 kJ mol^{-1}

C. 2.33 kJ mol^{-1}

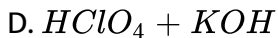
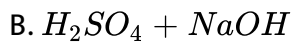
D. 1.5 kJ mol^{-1}

Answer: A



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45. In which of the following process of neutralization is the magnitude of $\Delta H_{\text{neutralization}}$ less than that of $\Delta H_{\text{ionization}}$ of water ?



Answer: C

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46. 2 mol of an ideal gas at $27^\circ C$ temperature is expanded reversibly from $2L$ to $20L$. Findk entropy change ($R = 2calmol^{-1}K^{-1}$)

A. 92.1

B. 0

C. 4

D. 9.2

Answer: D

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47. Heat of combustion ΔH° for $C(s)$, $H_2(g)$ and $CH_4(g)$ are 94, -68 and -213 Kcal/mol . Then ΔH° for $C(s) + 2H_2(g) \rightarrow \Delta CH_4(g)$ is

A. -17 kcal

B. -111 kcal

C. -170 kcal

D. -85 kcal

Answer: A

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48. In a closed insulated container, a liquid is stirred with a paddle to increase the temperature. Which of the following is true?

A. $\Delta U = W \neq 0, q = 0$

B. $\Delta U = W \neq 0 = q \neq 0$

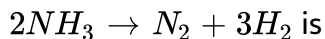
C. $\Delta U = 0, W = 0, q \neq 0$

D. $U = \Delta U = q \neq 0$

Answer: A

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49. The enthalpy of formation of ammonia is -46.2 mol^{-1} . The enthalpy change for the reaction



A. 42 kJ

B. 64 kJ

C. 80 kJ

D. 92 kJ

Answer: D



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50. Mechanical work is especially important in systems that contain

- A. solid-liquid
- B. liquid-liquid
- C. amalgam
- D. gases

Answer: D



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51. Enthalpy of neutralization of HCl with $NaOH$ is X . The heat evolved when 500 ml of $2NHCl$ is mixed with 250 ml of $4NNaOH$ will be

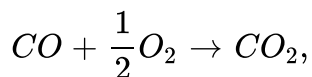
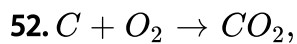
- A. $500X$
- B. $100X$

C. X

D. $10X$

Answer: D

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Then $\Delta_f H$ for CO will be

A. $2X + Y$

B. $X - Y$

C. $Y - 2X$

D. $Y - X$

Answer: D

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53. An adiabatic expansion of an ideal gas always has

A. decrease in temperature

B. $q = 0$

C. $W = 0$

D. $\Delta H = 0$

Answer: B



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54. For the transition

C (diamond) \rightarrow C (graphite), $\Delta H = -1.5\text{kJ}$

it follows that

A. diamond is exothermic

B. graphite is endothermic

C. graphite is more stable than diamond

D. diamond is more stable than graphite

Answer: C

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55. Enthalpy of $CH_4 + \frac{1}{2}O_2 \rightarrow CH_3OH$ is

negative. If enthalpy of combustion of CH_4 and CH_3OH are x and y respectively, then which relation is correct?

A. $X > Y$

B. $X < Y$

C. $X = Y$

D. $X \geq Y$

Answer: A

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56. Heat exchanged in a chemical in a chemical reaction at constant temperature and pressure is called

- A. entropy
- B. Enthalpy
- C. internal energy
- D. free energy

Answer: B



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57. When 1 mole of gas is heated at constant volume. Temperature is raised from 298 to 308K . Heat supplied to the gas is 500J . Then which stamenet is correct?

A. $q = W = 500J, \Delta U = 0$

B. $1 = \Delta U = 500J, W = 0$

C. $q = W = 500J, \Delta U = 500$

D. $\Delta U = 0, q = W = -500J$

Answer: B

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58. The heat of neutralization is maximum when

- A. ammonium hydroxide is neutralized by acetic acid
- B. ammonium hydroxide is neutralized by hydrochloric acid
- C. sodium hydroxide is neutralized by formic acid
- D. sodium hydroxide is neutralized by hydrochloric acid

Answer:

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59. The difference between ΔH and ΔU for the combustion of methane at $27^\circ C$ will be (in $Jmol^{-1}$)

A. $8.314 \times 27 \times -3$

B. $8.314 \times 300 \times (-3)$

C. $8.314 \times 300 \times (-2)$

D. $8.314 \times 300 \times 1$

Answer: C



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