



CHEMISTRY

BOOKS - CENGAGE CHEMISTRY

THERMODYNAMICS AND THERMOCHEMISTRY

Worked Examples

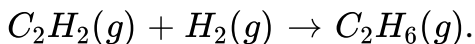
1. Enthalpies of combustion of carbon, hydrogen and methane are - 393 kJ, - 286 kJ, and -890 kJ, respectively. Calculate the enthalpy of formation of methane.

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2. Enthalpy of combustion of carbon , hydrogen and acetic acid are -393kj, -286 KJ, and -871 kj respectic acid .

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3. Calculate the enthalpy of the reacation .



Given enthalpy of combustion of ethaene , ethane, and hydrogen are - 140 kj , -1550 kj and - 286 kj, respectively .

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Mandatory Exercise Exercise Set I

1. A sample of an ideal gas is allowed to expand at constant temperature against atmospheric pressure.

(a) Does the gas work on its surroundings?

(b) Is there a heat exchange between the system and surroundings?

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2. Describe the interconversions of the forms of energy occurring in these processes.

(a) Throw a softball up into the air and catch it. (b) Switch on a flashlight.

(c) Strike a match and let it burn down.

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3. In writing thermochemical equations, why is it important to indicate the physical state of each substance?

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4. In an exothermic reaction

- A. the energy of the reactants is more than that of the products.
- B. the energy of the reactants is less than that of the products.
- C. the energy of the reactants may be more or less than that of the products, depending on the temperature.
- D. energy of the reactants and products are the same.

Answer: A



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5. Compounds formed by the absorption of heat from their elements are called

- A. exothermic compounds
- B. endothermic compounds

C. efflorescent compounds

D. deliquescent compounds

Answer: B

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6. An example for an endothermic reaction is the combination of

A. carbon- and oxygen-yielding carbon dioxide

B. nitrogen- and hydrogen yielding ammonia

C. nitrogen- and oxygen yielding nitric oxide

D. hydrogen- and oxygen yielding water

Answer: C

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7. For an endothermic reaction

A. ΔH is negative

B. ΔH is positive

C. ΔE is negative

D. Zero

Answer: B



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8. Thermodynamics is concerned with,

A. Total energy of a system

B. Energy changes in a system

C. Rate of a chemical change

D. Mass change in nuclear reactions

Answer: B



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9. An isolated system is that system in which

- A. There is no exchange of energy with the surrounding
- B. There is exchange of mass and energy with the surrounding
- C. There is no exchange of energy and mass with the surrounding
- D. There is exchange of mass and energy

Answer: C



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10. For a cyclic process the condition is

A. $\Delta E = 0$

B. $\Delta H = 0$

C. $\Delta E > 0$

D. both $\Delta E = 0$ and $\Delta H = 0$

Answer: D



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11. Identify the intensive property from the following.

A. Enthalpy and temperature

B. Volume and temperature

C. Enthalpy and volume

D. Temperature and refractive index

Answer: C



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12. If A and B are extensive property, then which one is intensive.

A. $A \div B$

B. $A - B$

C. $A \times B$

D. $\frac{A}{B}$

Answer: D



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13. Ratio of ΔE and number of mole is.

A. Extensive

B. Intensive

C. depends on n

D. depends on temperature

Answer: B



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14. The mathematical form of the first law of thermodynamic is

A. $\Delta E = q + w$

B. $\Delta E = q - w$

C. $\Delta E = w - q$

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

Answer: A



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15. For isothermal process

A. $\Delta E = 0$

B. $\Delta E = +ve$

C. $\Delta E = -ve$

D. none

Answer: A



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16. In Case of closed container

A. $\Delta E = -w$

B. $\Delta E = -q$

C. $\Delta E = q$

D. $w = q$

Answer: C



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17. In case of adiabatic process

A. $\Delta V = q$

B. $q + w = 0$

C. $q = w$

D. $\Delta E = w$

Answer: D



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18. A system absorbs 500kJ heat and performs 250 kJ work on the surrounding, change in Internal energy is .

A. $+750Kj$

B. $+250kj$

C. $-250kj$

D. $-750kj$

Answer: C



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19. Which of the following is a state function?

A. heat

B. work

C. internal energy

D. none

Answer: C



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20. Internal energy of a system do not include

- A. kinetic energy
- B. vibrational energy
- C. rotational energy
- D. none

Answer: D



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21. Work done against vacuum is

- A. $+ve$
- B. $-ve$

C. zero

D. can't prediabatically

Answer: D



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22. When an ideal gas is compressed adiabatically and reversibly, the final temperature is.

A. higher than the initial temperature

B. lower than the initial temperature

C. the same as initial temperature

D. depends upon the rate of compression

Answer: A



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23. An exothermic reaction is one in which the reacting substance.

- A. have same energy as product
- B. less same energy than the product
- C. have more energy than the product
- D. are at higher temperature than the products

Answer: C



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24. In endothermic reactions, the reactants

- A. have more energy than products
- B. have as much energy as the products
- C. are at low temperature than products

D. have less energy than the products

Answer: D

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25. Evaporation of water is

A. chemical reaction

B. exothermic

C. endothermic

D. Thermochemical reaction

Answer: C

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26. The enthalpies of all elements in their standard state at $25^{\circ}C$ and one atmospheric pressure are

- A. same
- B. always $+ve$
- C. always $-ve$
- D. Zero

Answer: D



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27. Which of the following have zero enthalpy of formation .

- A. $Br_2(g)$
- B. $Br_2(l)$
- C. both

D. none

Answer: C

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Mandatory Exercise Exercise Set II

1. Define

A. enthalpy and reaction

B. enthalpy of neutralisation

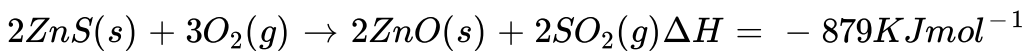
C. enthalpy

D. none

Answer: D

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2. The first step in the industrial recovery of zinc , the zinc sulphide ore is roasting i.e., the conversion of zinc sulphide to zinc oxide .



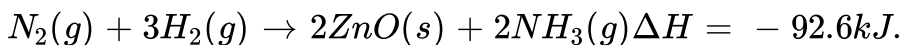
Calculate the heat evolved per gram of zinc sulphide .

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3. The enthalpy of formation of ethanol , carbon dioxide and water are - 287 kJ, - 393 kJ and -286 kJ respectively . Calculate the enthalpy of combustion of ethanol .

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4. Calculate the amount of heat liberated when 1.26×10^4 g of ammonia is produced according to the equation.





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5. Methanol is an organic solvent and is also used as a fuel in some automobile engines. Standard enthalpies of combustion of methanol, carbon, and hydrogen are -764 kJ, -393.5 kJ, -286 kJ, respectively. Calculate the standard enthalpy of formation of methanol.



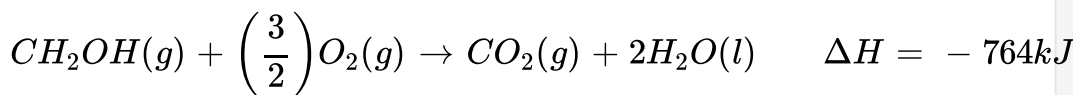
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6. Acetylene can be obtained by the reaction between calcium carbide and water. Calculate the maximum amount of heat that can be obtained from the combustion of acetylene starting with 74.6 g of calcium carbide (CaC_2). The enthalpy of combustion of acetylene is -1300 kJ).



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7. Methanol is an efficient fuel that can be produced from coal and hydrogen.



(a) Find the heat evolved when 110 g of methanol is burnt in excess of oxygen.

(b) Calculate the mass of oxygen consumed to produce 975 kJ of heat.

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8. Calculate the enthalpy of formation of ethane. The enthalpy of combustion of ethane, carbon, and hydrogen are -1550 kJ, -393 kJ, and -286 kJ, respectively.

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9. Hydrogen is used as a rocket fuel. The hydrogen is burnt in oxygen to produce water vapour.

$2H_2(g) + O_2(g) \rightarrow 2H_2O(g)$ $\Delta H = -484kJ$. Calculate the enthalpy change for one gram of hydrogen.

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10. The enthalpy change of a reaction represents.

- A. change in the concentration of the reactants
- B. difference in the heat contents of the product and the reactants
- C. difference in the number of moles of the reactants and products
- D. all of these

Answer: B



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11. Enthalpy of an element in the standard state is

- A. greater than zero
- B. less than zero
- C. zero
- D. greater or less than zero

Answer: C



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12. Heat of formation of compound is equal to the heat of decomposition into elements. This is stated by

A. law of conservation of energy

B. law of mass action

C. Laplace law

D. Hess' law

Answer: C



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13. The enthalpy of combustion of a substance is

A. always positive

B. always negative

C. may be positive or negative

D. always zero

Answer: B



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14. When a gram atom of carbon is converted into a gram molecule of carbon dioxide, the heat liberated is the same

- A. irrespective of whether the volume or pressure is kept constant
- B. irrespective of the temperature at which the reaction was carried out
- C. whether the carbon taken was graphite or diamond
- D. whether the reaction was carried out in one step or whether the carbon was first converted to carbon monoxide and then to carbon dioxide

Answer: D



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15. The enthalpy of formation of HI is +30.4 kJ. From this information which of the following statements is wrong?

A. HI is an endothermic compound.

B. HI is a stable compound.

C. HI is an unstable compound.

D. $H_2(g) + I_2(g) \rightarrow 2HI(g)$, $\Delta H = +60.8kJ$

Answer: C



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16. Standard molar enthalpy of formation of CO_2 , is equal to

A. standard molar enthalpy of combustion of carbon (graphite)

B. zero

C. the standard molar enthalpy of combustion of gaseous carbon

D. the sum of standard molar enthalpy of combustion of CO and



Answer: A



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17. Heat of formation (ΔH_f) of compounds are:

A. always +ve

B. always -ve

C. zero

D. may be +ve and -ve

Answer: D



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18. Difference between heat of reaction at constant pressure and constant volume for the reaction.

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

A. + 7.43

B. + 3.72

C. - 7.43

D. - 3.72

Answer: D



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19. Reaction $H_2(g) + I_2(g) \rightarrow 2HI$, $\Delta H_{rxn} = 12.40\text{Kcal}$ heat of formation of HI will be

A. 12.40 Kcal

B. -12.4 Kcal

C. -6.20 Kcal

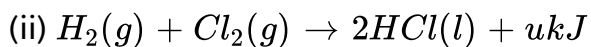
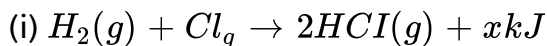
D. 6.20 Kcal

Answer: D



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20. For the reaction.



A. $x > y$

B. $x < y$

C. $x - y = 0$

D. $x = y$

Answer: B



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21. The amount of heat liberated when one mole of NH_4OH reacts with one mole of HCl is

- A. 13.7 kcal
- B. more than 13.7 kcal
- C. less than 13.7 kcal
- D. can't be predicted

Answer: B



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22. $\Delta H_{\text{neutralisation}}$ for the reaction .



The heat released when 0.25 mole of NaOH is titrated against 0.25 mole of HCl will be

- A. 22.5 kJ
- B. 57.1 kJ
- C. 28.6 kJ
- D. 14.3 kJ

Answer: D

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23. Hess's law deals with

- A. change in heat of reaction

B. rate of reaction

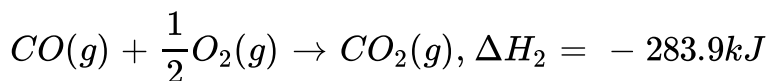
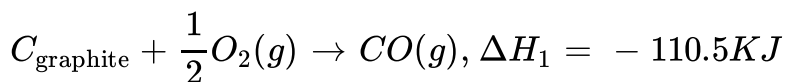
C. equilibrium constant

D. Influence of pressure on gas

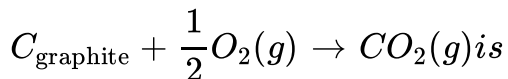
Answer: A

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24. From the thermo chemical reaction



Then heat reaction of



A. + 393.7 kJ

B. - 393kJ

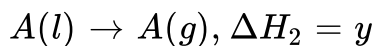
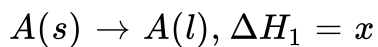
C. - 172.7kJ

D. $+172.7\text{kJ}$

Answer: C

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25. Given that



The heat of sublimation of A will .

A. $x + y$

B. $x - y$

C. x or y

D. $-(x + y)$

Answer: A

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26. On combustion carbon forms two oxides CO and CO_2 heat of formation of CO_2 is -94.3 kcal and that CO is -26.0 kcal. Heat of combustion of carbon is .

- A. 26.0 Kcal
- B. -68.3 kcal
- C. -94.3 Kcal
- D. -120.3 Kcal

Answer: C



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27. Heat evolved in calorie by the combustion of 1g of a fuel is called

- A. heat of combustion

B. calorific value

C. heat of formation

D. none

Answer: B



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28. When 5 ml of a strong acid is added to 5 ml of an alkali the temperature rises by $T^{\circ}C$. If 10 ml of the same acid is mixed with 10 ml of the same base the temperature rise would be

A. T

B. 2T

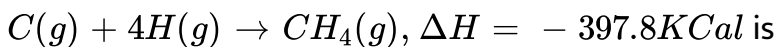
C. 3T

D. 4T

Answer: A

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29. The bond dissociation energy of C-H in CH_4 , from the equation .



A. + 99.45 Kcal

B. - 99.45 kcal

C. + 397.8 Kcal

D. + 198.9 Kcal

Answer: A

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30. Energy required to dissociate 4 g of gaseous hydrogen into free gaseous atom is 208 Kcal at $25^{\circ}C$. The bond energy of H-H bond will be

- A. 1.04 Kcal
- B. 10.4 Kcal
- C. 104 Kcal
- D. 1040 Kcal

Answer: A

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31. ΔH and ΔE for the reaction $S(s) + \frac{3}{2}(g) \rightarrow SO_3(g)$ are related as

- A. $\Delta H = \Delta E - 0.5RT$

B. $\Delta H = \Delta E - 1.5RT$

C. $\Delta H = \Delta E + RT$

D. $\Delta H = \Delta E + 1.5RT$

Answer: A

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32. The enthalpy of formation of a compound is equal in magnitude but of opposite sign to the enthalpy of decomposition of that compound under the same conditions. This law was presented by

A. Hess

B. Le-chatelier's

C. Kirchhoff

D. Lavoisier and Laplace

Answer: D

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33. The change of enthalpy of a chemical reaction is the same whether the reaction takes place in one step or in several steps. This law was presented by

- A. Hess
- B. Le Chatelier's
- C. Van't Hoff
- D. Kirchhoff

Answer: A

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Consolidated Exercise

1. Calculate the enthalpy change for the reaction .

$H_2(g) + Br_2(g) \rightarrow 2HBr(g)$ Given that the bond energies of H-H, H-Br, and Br-Br are $435kJmol^{-1}$, $364kJmol^{-1}$, and $192kJmol^{-1}$, respectively.

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2. Calculate the enthalpy of formation of water, given that the bond energies of H-H, O=O, and O-H bond are $433kJmol^{-1}$, $492kJmol^{-1}$, and $464kJmol^{-1}$, respectively.

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3. ΔH for the reaction.

$HCN(g) + 2H_2(g) \rightarrow CH_3NH_2(g)$ is -150 kJ.

Calculate the bond energy of $-C = N$ bond.

[Given bond energies of $C - H = 414 \text{ kJ mol}^{-1}$ $H-H = 435 \text{ kJ mol}^{-1}$,

$C-N = 293 \text{ kJ mol}^{-1}$ $N-H = 396 \text{ kJ mol}^{-1}$

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4. Match the following.



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5. Which of the following is/are state function(s)?

A. Internal energy (U)

B. Volume (V)

C. Heat (q)

D. Enthalpy (H)

Answer: A::B

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6. Which of the following is/are endothermic reaction(s)?

- A. Combustion of methane
- B. Decomposition of water
- C. Dehydrogenation of ethane to ethene
- D. Conversion of graphite to diamond

Answer: C::D

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7. Which of the following are intensive properties?

A. Temperature

B. Pressure

C. Density

D. enthalpy

Answer: B::C

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Challenging Exercise

1. A gas mixture containing 3.5 L of ethylene and methane on complete combustion at 298 K produce 6 L of carbon dioxide. Find the amount of heat evolved on burning one litre of the gas mixture. The enthalpy of combustion of ethylene and methane are - 1423 kJ and -890 kJ, respectively.

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2. A person consumes 250 g of cheese which is equivalent to 4000 kJ of energy. Suppose none of the energy was stored in his body, what mass of water would he need to perspire in order to maintain his original temperature?

[Given $H_2O(l) \rightarrow H_2O(g) \Delta H = 44kJ$]



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3. The enthalpy of transition of red phosphorus to white phosphorus is +16.4 kJ. What conclusion can you draw from this statement?



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4. An adult, on an average, needs 4500 kJ of energy per day for his normal activities. Carbohydrates provide 60% energy. If the standard

enthalpy of combustion of glucose is 2850 kJ, calculate the mass of glucose to be consumed per day to meet this energy.

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5. A sports person is given 100 g of glucose of energy equivalent to 1590 kJ. In an event 50% of this energy is used by him. Calculate the mass of water he would need to perspire in order to avoid storage of energy in the body. The enthalpy of vaporisation of water is 44 kJ.

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6. Natural gas of 10 L measured at STP on complete combustion produces 475 kJ of heat. The enthalpy of combustion of methane and ethane are -894 kJ and -1560 kJ, respectively. Calculate the percentage by volume of each gas in the mixture assuming the sample of natural gas consists of only methane and ethane.



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7. A sample of natural gas is 80% methane and 20% ethane by mass. Calculate the heat produced when 1 g of the mixture is burnt completely in air.

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Olympiad And Ntse Level Exercises

1. Which is not intensive property?

- A. Boiling point
- B. Refractive index
- C. Molarity
- D. Volume

Answer: D



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2. 1 g H_2 gas STP is expanded so that the volume is doubled. Hence, work done is

A. 22.4 L-atm

B. 5.6 L-atm

C. 11.2 L-atm

D. 44.8 L-atm

Answer: C



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3. Temperature of 1 mol of a gas is increased by 1° at constant pressure. The work done is.

A. R

B. 2R

C. R/2

D. 3R

Answer: B



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4. $\Delta_f H(H_2O) = -68 \text{ kcal mol}^{-1}$ and ΔH of neutralisation is $-13.7 \text{ kcal mol}^{-1}$, then the heat of formation of $\overset{\ominus}{O}H$ is

A. $-68 \text{ kcal mol}^{-1}$

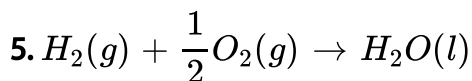
B. $-54.3 \text{ kcal mol}^{-1}$

$$C. 54.3 \text{ kcal mol}^{-1}$$

$$D. -71.7 \text{ kcal mol}^{-1}$$

Answer: B

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$$BE(H - H) = x_1, BE(O = O) = x_2$$

$$BE(O - H) = x_3$$

Latent heat of vaporisation of water liquid into water vapour = x_4

then $\Delta_f H$ (heat of formation of liquid water) is

$$A. x_1 = \frac{x_2}{2} - x_3 + x_4$$

$$B. 2x_3 - x_1 - \frac{x_2}{2} - x_4$$

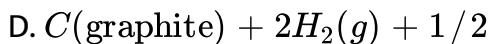
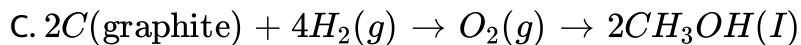
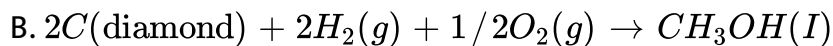
$$C. x_1 + \frac{x_2}{2} - 2x_3 - x_4$$

$$D. x_1 + \frac{x_2}{2} - 2x_3 + x_4$$

Answer: C

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6. Which of the following equations corresponds to the definition of enthalpy of formation at 298 K?



Answer: D

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7. When a reaction is carried out in a closed vessel.

A. $q_p < q_v$

B. $q_p > q_v$

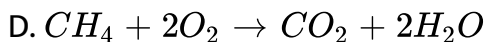
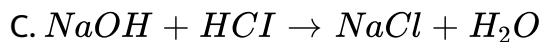
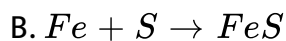
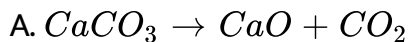
C. $q_p = q_v$

D. $q_v = 0$

Answer: C

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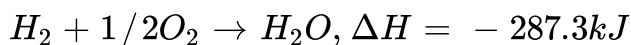
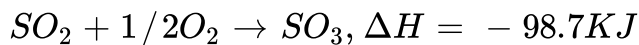
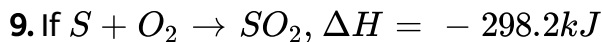
8. Which of the following reaction is endothermic ?



Answer: A



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Then the enthalpy of formation of H_2SO_4 at 298 K is .

A. -814.4 kJ

B. -650.3 kJ

C. -320.5 kJ

D. -233.5 kJ

Answer: A



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10. Standard molar enthalpy of formation of CO_2 is equal to .

A. Zero

B. The standard molar enthalpy of combustion of gaseous carbon

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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