6. Thermodynamics and Thermochemistry – Multiple Choice Questions

1. Basic Concepts

1. Conditions of standard state used in thermochemistry is

(a) $0^{o}C$ and 1 atm
(b) $20^{o}C$ and 1 atm
(c) $25^{o}C$ and 1 atm
(d) $0K$ and 1 atm

2. The temperature of the system decreases in an

(a) Adiabatic compression
(b) Isothermal compression
(c) Isothermal expansion
(d) Adiabatic expansion

3. The cooling in refrigerator is due to

(a) Reaction of the refrigerator gas
(b) Expansion of ice
(c) The expansion of the gas in the refrigerator
(d) The work of the compressor

4. It is general principle that the less energy a system contains, it is

(a) Less stable
(b) More stable
(c) Unstable
(d) More unstable

5. Which of the following is true for an adiabatic process

(a) $\Delta H = 0$
(b) $\Delta W = 0$
(c) $\Delta Q = 0$
(d) $\Delta V = 0$

6. For a cyclic process

(a) $W = 0$
(b) $\Delta E = 0$
(c) $\Delta H \neq 0$
(d) $\Delta E \neq 0$

7. Identify an extensive property amongst the following

(a) Viscosity
(b) Heat capacity
(c) Density
(d) Surface tension

8. In an isothermal process

(a) $q = 0$ and $\Delta E = 0$
(b) $q \neq 0$ and $\Delta E = 0$
(c) $q = 0$ and $\Delta E \neq 0$
(d) $q \neq 0$ and $\Delta E \neq 0$

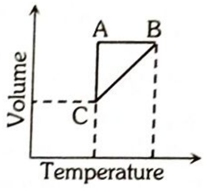
9. The heat change at constant volume (q_v) is equal to

(a) ΔU
(b) ΔH
(c) RT
(d) ΔG

10. An ideal gas at constant temperature and pressure expands, then its

(a) Internal energy remains same
(b) Internal energy decreases
(c) Internal energy increases
(d) Entropy first increases and then decreases

11. Five moles of a gas is put through a series of changes as shown graphically in a cyclic process the $A \to B$, $B \to C$ and $C \to A$ respectively are



(a) Isochoric, Isobaric, Isothermal
(b) Isobaric, Isochoric, Isothermal
(c) Isothermal, Isobaric, Isochoric
(d) Isochoric, Isothermal, Isobaric

12. Thermodynamics is not concerned about

(a) Energy changes involved in a chemical reaction
(b) The extent to which a chemical reaction proceeds
(c) The rate at which a reaction proceeds
(d) The feasibility of a chemical reaction

13. Which of the following statement is correct

(a) The presence of reacting species in a covered beaker is an example of open system
(b) There is an exchange of energy as well as matter between the system and the surroundings in a closed system
(c) The presence of reactants in a closed vessel made up of copper is an example of a closed system
(d) The presence of reactants in a thermos flask or any other closed insulated vessel is an example of a closed system

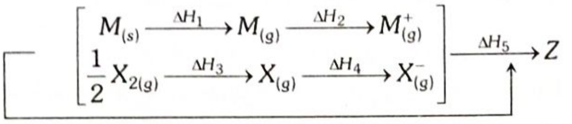
14. The state of a gas can be described by quoting the relationship between

(a) Pressure, volume, temperature
(b) Temperature, amount, pressure
(c) Amount, volume, temperature
(d) Pressure, volume, temperature, amount

15. If a refrigerator's door is opened, then we get

(a) Room heated
(b) Room cooled
(c) More amount of heat is passed out
(d) No effect on room

16. Consider the Born– Haber cycle for the formation of an ionic compound given below and identify the compound (Z) formed.



(a) MX
(b) $M^+X^-_{(g)}$
(c) $M^+X^-{}_{(s)}$
(d) $M^-X^-_{(s)}$

17. Among the quantities, density (ρ), temperature (T), enthalpy (H), heat capacity (C_p), volume (V) and pressure (P), a set of intensive variables are

(a) (ρ, T, H)
(b) (H, T, V)
(c) (V, T, C_p)
(d) (ρ, T, P)

2. First Law of Thermodynamics and Hess Law

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

(a) Constant pressure
(b) Constant temperature
(c) Constant temperature and pressure
(d) Constant temperature, pressure and composition

2. For the reaction $A(g) + 2B(g) \rightarrow 2C(g) + 3D(g)$, the value of ΔE at $27°C$ is 19.0 *kcal*. The value of ΔH for the reaction would be $(R = 2.0\, cal\, K^{-1} mol^{-1})$

(a) 20.8 *kcal*
(b) 19.8 *kcal*
(c) 18.8 *kcal*
(d) 20.2 *kcal*

3. For the process dry ice $\longrightarrow CO_2(g)$

(a) ΔH is positive while ΔP is negative
(b) Both ΔH and ΔP are negative
(c) Both ΔH and ΔP are positive
(d) ΔH is negative while ΔP is positive

4. A 1.0 *g* sample of substance *A* at 100°C is added to 100 *mL* of H_2O at 25°C. Using separate 100 *mL* portions of H_2O, the procedure is repeated with substance *B* and then with substance *C*. How will the final temperature of the water compare

Substance	**Specific Heat**
A	$0.60\, Jg^{-1}°C^{-1}$
B	$0.40\, Jg^{-1}°C^{-1}$
C	$0.20\, Jg^{-1}°C^{-1}$

(a) $T_C > T_B > T_A$
(b) $T_B > T_A > T_C$
(c) $T_A > T_B > T_C$
(d) $T_A = T_B = T_C$

5. A mixture of two moles of carbon monoxide and one mole of oxygen, in a closed vessel is ignited to convert the carbon monoxide to carbon dioxide. If ΔH is the enthalpy change and ΔE is the change in internal energy, then

(a) $\Delta H > \Delta E$
(b) $\Delta H < \Delta E$
(c) $\Delta H = \Delta E$
(d) The relationship depends on the capacity of the vessel

6. The standard enthalpy of formation of which of the following is zero

(a) CH_3OH
(b) HF
(c) H_2O
(d) F_2

7. ΔE^o of combustion of isobutylene is $-X\, kJ\, mol^{-1}$. The value of ΔH^o is

(a) $= \Delta E^o$
(b) $> \Delta E^o$
(c) $= 0$
(d) $< \Delta E^o$

8. The work done by the gas liberated when 50 g of iron (molar mass 55.85g mol^{-1} reacts with hydrochloric acid in an open beaker at $25°C$

(a) Zero
(b) $-2.2\, kJ$
(c) $2.2\, kJ$
(d) $0.22\, kJ$

9. For isothermal expansion of an ideal gas, the correct combination of the thermodynamic parameters will be

(a) $\Delta U = 0, Q = 0, w \neq 0$ and $\Delta H \neq 0$
(b) $\Delta U \neq 0, Q \neq 0, w \neq 0$ and $\Delta H \neq 0$
(c) $\Delta U = 0, Q \neq 0, w = 0$ and $\Delta H \neq 0$
(d) $\Delta U = 0, Q \neq 0, w \neq 0$ and $\Delta H = 0$

10. Pressure-volume (PV) work done by an ideal gaseous system at constant volume is (where E is internal energy of the system)

(a) $-\Delta P / P$
(b) Zero
(c) $-V\Delta P$
(d) $-\Delta E$

11. A sample of liquid in a thermally insulated container is stirred for 1 *hr* by a mechanical attachment to a motor in the surroundings, which of the following thermodynamic quantity for the system is zero

(a) Work (W)
(b) Change in internal energy (ΔE)
(c) Change in enthalpy (ΔH)
(d) None of these

12. On the basis of theromochemical equations (i), (ii) and (iii), find out which of the algebraic relationships given in options (a) to (d) is correct

(i) $C\text{ (graphite) } + O_2(g) \rightarrow CO_2(g); \Delta_r H = x kJ\ mol^{-1}$

(ii) $C\text{ (graphite) } + \frac{1}{2}O_2(g) \rightarrow CO(g); \Delta_r H = y kJ\ mol^{-1}$

(iii) $CO(g) + \frac{1}{2}O_2(g) \rightarrow CO_2(g); \Delta_r H = z kJ\ mol^{-1}$

(a) $z = x + y$ (b) $x = y - z$

(c) $x = y + z$ (d) $y = 2z - x$

13. In an adiabatic process, no transfer of heat takes place between system and surroundings. Choose the correct option for free expansion of an ideal gas under adiabatic condition from the following

(a) $q = 0, \Delta T \neq 0, W = 0$ (b) $q \neq 0, \Delta T = 0, W = 0$

(c) $q = 0, \Delta T = 0, W = 0$ (d) $q = 0, \Delta T < 0, W \neq 0$

14. Joule-Thomson expansion is

(a) Isobaric (b) Isoenthalpic

(c) Isothermal (d) None of these

15. Which one of the following equations does not correctly represent the first law of thermodynamics for the given process

(a) Isothermal process : $q = -w$

(b) Cyclic process : $q = -w$

(c) Isochoric process : $\Delta E = q$

(d) Adiabatic process : $\Delta E = -w$

(e) Expansion of a gas into vacuum : $\Delta E = q$

16. Which expression is correct for the work done in adiabatic reversible expansion of an ideal gas

(a) $W = nRT \ln \frac{V_2}{V_1}$ (b) $W = n_e \ln \frac{T_2}{T_1}$

(c) $W = P\Delta V$ (d) $W = -\int_1^2 PdV$

17. The pressure-volume work for an ideal gas can be calculated by using the expression $W = -\int_{V_i}^{V_f} P_{ex} dV$. The work can also be calculated from the pV – plot by using the area under the curve within the specified limits. When an ideal gas is compressed (a) reversibly or (b) irreversibly from volume V_i to V_f. Choose the correct option

(a) W (reversible) = W (irreversible)

(b) W (reversible) < W (irreversible)

(c) W (reversible) > W (irreversible)

(d) W (reversible) = W (irreversible) $+ P_{ex}.\Delta V$

18. For an ideal gas, which of the following is true

(a) $\left(\frac{\partial E}{\partial V}\right)_T > 0$ (b) $\left(\frac{\partial P}{\partial V}\right)_T = 0$

(c) $\left(\frac{\partial E}{\partial V}\right)_T = 0$ (d) $\left(\frac{\partial (PV)}{\partial V}\right)_T > 0$

19. In an isobaric process, the ratio of heat supplied to the system (dQ) and work done by the system (dW) for diatomic gas is

(a) 1 : 1 (b) 7 : 2

(c) 7 : 5 (d) 5 : 7

20. The entropy change in the isothermal reversible expansion of 2 moles of an ideal gas from 10 to 100 L at 300 K is

(a) $42.3\,J\,K^{-1}$ (b) $35.8\,J\,K^{-1}$

(c) $38.3\,J\,K^{-1}$ (d) $32.3\,J\,K^{-1}$

21. For the isothermal reversible expansion of an ideal gas

(a) $\Delta H > 0$ and $\Delta U = 0$ (b) $\Delta H > 0$ and $\Delta U < 0$

(c) $\Delta H = 0$ and $\Delta U = 0$ (d) $\Delta H = 0$ and $\Delta U > 0$

3. II^nd & III^rd Law of Thermodynamics and Entropy

1. When you freeze water in your freezer to make ice cubes, the amount of order in the molecules of water increases. However, second law of thermodynamics says that the amount of order in an isolated system can only stay constant or decrease with time. How can this making of ice violates second law

(a) Because water expands during ice formation

(b) Because ice formation takes place at 0°C

(c) Because ice is solid

(d) Because ice cubes do not constitute isolated system

2. Which of the following statement is true. The entropy of the universe

(a) Increases and tends towards maximum value

(b) Decreases and tends to be zero

(c) Remains constant

(d) Decreases and increases with a periodic rate

3. Which is the correct expression, that relates changes of entropy with the change of pressure for an ideal gas at constant temperature in the following

(a) $\Delta S = nRT \ln \frac{P_2}{P_1}$ (b) $\Delta S = T(P_2 - P_1)$

(c) $\Delta S = nR \ln \frac{P_1}{P_2}$ (d) $\Delta S = 2.303 nRT \ln \frac{P_1}{P_2}$

4. One mole of which of the following has the highest entropy

(a) Mercury
(b) Diamond
(c) Liquid nitrogen
(d) Hydrogen gas

5. Entropy change in a process where 1 litre of liquid He is poured into ice cold water is

(a) Finite and positive
(b) Finite and negative
(c) Zero
(d) Infinity

6. The change of entropy (dS) is defined as

(a) $dS = \delta q / T$
(b) $dS = dH / T$
(c) $dS = \delta q_{rev} / T$
(d) $dS = (dH - dG)/T$

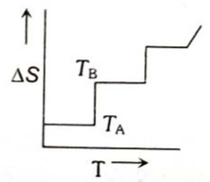
7. In which of the following entropy decreases

(a) Crystallization of sucrose from solution
(b) Rusting of iron
(c) Melting of ice
(d) Vaporization of camphor

8. For conversion C (graphite) $\rightarrow C$ (diamond) the ΔS is

(a) Zero
(b) Positive
(c) Negative
(d) Unknown

9. If for a given substance melting point is T_B and freezing point is T_A, then correct variation shown by graph between entropy change and temperature is

(a)


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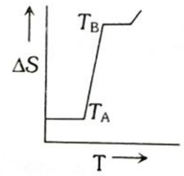

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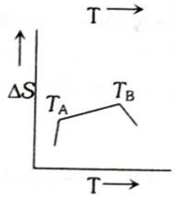

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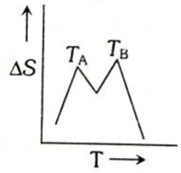


10. Mixing of non-reacting gases is generally accompanied by

(a) Decrease in entropy
(b) Increase in entropy
(c) Change in enthalpy
(d) Change in free energy

11. An irreversible process occurring isothermally in an isolated system leads to

(a) Zero entropy
(b) An increase in the total entropy of the system
(c) A decrease in the total entropy of the system
(d) None of these

12. For chemical reactions, the calculation of change in entropy is normally done

(a) At constant pressure
(b) At constant temperature
(c) At constant temperature and pressure both
(d) At constant volume

13. For reaction $2Cl(s) \rightarrow Cl_2(s)$, the signs of ΔH and ΔS respectively are

(a) +, −
(b) +, +
(c) −, −
(d) −, +

14. A container has hydrogen and oxygen mixture in ratio of 4 : 1 by weight, then

(a) Internal energy of the mixture decreases
(b) Internal energy of the mixture increases
(c) Entropy of the mixture increases
(d) Entropy of the mixture decreases

15. Entropy changes for the process, $H_2O_{(l)} \rightarrow H_2O_{(s)}$ at normal pressure and 274 K are given below $\Delta S_{\text{system}} = -22.13$, $\Delta S_{\text{surr}} = +22.05$, the process is non-spontaneous because

(a) ΔS_{system} is − ve
(b) ΔS_{surr} is +ve
(c) ΔS_{u} is − ve
(d) $\Delta S_{\text{system}} \neq \Delta S_{\text{surr}}$

16. The entropy change can be calculated by using the expression $\Delta S = \frac{q_{rev}}{T}$ when water freezes in a glass beaker, choose the correct statement amongst the following

(a) ΔS (system) decreases but ΔS (surroundings) remains the same
(b) ΔS (system) increases but ΔS (surroundings) decreases
(c) ΔS (system) decreases but ΔS (surroundings) increases
(d) ΔS (system) decreases but ΔS (surroundings) also decreases

17. For an isolated system, $\Delta U = 0$, then

(a) $\Delta S = 0$
(b) $\Delta S < 0$
(c) $\Delta S \geq 0$
(d) The value of ΔS cannot be predicted

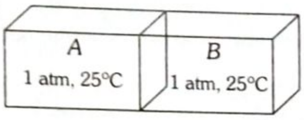
18. Under equilibrium conditions, which of the following is true

(a) $\Delta S = 0$
(b) $\Delta H > 0$
(c) $\Delta S > 0$
(d) $\Delta H < 0$

19. A concentrated solution of copper sulphate, which is dark blue in colour, is mixed at room temperature with a dilute solution of copper sulphate, which is light blue. For this process

(a) Entropy change is positive, but enthalpy change is negative
(b) Entropy and enthalpy changes are both positive
(c) Entropy change is positive and enthalpy does not change
(d) Entropy change is negative and enthalpy change is positive

20. As isolated box, equally partitioned contains two ideal gases A and B as shown



When the partition is removed, the gases mix. The changes in enthalpy (ΔH) and entropy (ΔS) in the process, respectively, are

(a) Zero, positive (b) Zero, negative

(c) Positive, zero (d) Negative, zero

21. For a process to occur spontaneously

(a) Only the entropy of the system must increase

(b) Only the entropy of the surroundings must increase

(c) Either the entropy of the system or that of the surroundings must increase

(d) The total entropy of the system and the surroundings must increase

22. The latent heat of melting of ice at $0°C$ is $6\,kJ\,mol^{-1}$. The entropy change during the melting in $JK^{-1}\,mol^{-1}$ is closest to

(a) 22 (b) 11

(c) −11 (d) −11

4. Heat of Reaction

1. The enthalpy of combustion at 25°C of H_2, cyclohexane (C_6H_{12}) and cyclohexene (C_6H_{10}) are −241, −3920 and −3800 $KJ / mole$ respectively. The heat of hydrogenation of cyclohexene is

(a) $-121\ KJ/mole$ (b) $+121\ KJ/mole$

(c) $-242\ KJ/mole$ (d) $+242\ KJ/mole$

2. Heat of neutralization of NH_4OH and HCl is

(a) $13.7\,kcal$ (b) $>13.7\,kcal$

(c) $<13.7\,kcal$ (d) None of the above

3. The energy released on combustion of 1 mole of $C_{(s)}$ with gaseous oxygen is

(a) $\Delta H^{\circ}_{\text{combustion}}$ (b) $\Delta H^{\circ}_{\text{formation}}$ of CO_2

(c) Both are true (d) None is true

4. When 5 litres of a gas mixture of methane and propane is perfectly combusted at $0°C$ and 1 atmosphere, 16 litres of oxygen at the same temperature and pressure is consumed. The amount of heat released from this combustion in kJ

$[\Delta H_{\text{comb.}}(CH_4) = 890\,kJ\,mol^{-1},\ \Delta H_{\text{comb.}}(C_3H_8) = 2220\,kJ$

$mol^{-1}]$ is

(a) 38 (b) 317

(c) 477 (d) 32

5. In the reaction for the transition of carbon in the diamond form to carbon in the graphite form, ΔH is $-453.5\,cal$. This points out that

(a) Graphite is chemically different from diamond

(b) Graphite is as stable as diamond

(c) Graphite is more stable than diamond

(d) Diamond is more stable than graphite

6. For an exothermic reaction

(a) H of the products is less than H of the reactants

(b) H of the products is more than H of the reactants

(c) H of the products is equal to H of the reactants

(d) ΔH is always positive

7. Calculate the standard heat of formation of carbon disulphide (l), given that the standard heat of combustion of carbon (s), sulphur (s) and carbon disulphide (l) are $-393.3, -293.72$ and $-1108.76\,kJ\,mol^{-1}$ respectively

(a) $-128.02\,kJ\,mol^{-1}$ (b) $+12.802\,kJ\,mol^{-1}$

(c) $+128.02\,kJ\,mol^{-1}$ (d) $-12.802\,kJ\,mol^{-1}$

8. When 400 mL of 0.2 N solution of a weak acid is neutralized by a dilute aqueous solution of sodium hydroxide under standard conditions, 4.4 kJ amount of heat is liberated. Therefore, the standard enthalpy of neutralization of this weak acid in $kJ\,eq^{-1}$ is

(a) −11 (b) −44

(c) −55 (d) −22

9. The values of ΔH for the combustion of ethene and ethyne are − 341.1 and − 310.0$kcal$ respectively. Which of the following is a better fuel

(a) C_2H_2 (b) C_2H_4

(c) Both of these (d) None of these

10. In which of the following reactions, the heat liberated is known as "heat of combustion"

(a) $H^{+}{}_{(aq)} + OH^{-}{}_{(aq)} \longrightarrow H_2O_{(l)} + \text{heat}$

(b) $C(\text{graphite}) + \frac{1}{2}O_{2\,(g)} \longrightarrow CO_{(g)} + \text{heat}$

(c) $CH_{4\,(g)} + 2O_{2\,(g)} \longrightarrow CO_{2\,(g)} + 2H_2O_{(l)} + \text{heat}$

(d) $H_2SO_{4\,(aq)} + H_2O_{(l)} \longrightarrow H_2SO_{4\,(aq)} + \text{heat}$

11. Compounds with high heat of formation are less stable because

(a) High temperature is required to synthesise them

(b) Molecules of such compounds are distorted

(c) It is difficult to synthesis them

(d) Energy rich state leads to instability

12. Sodium chloride is soluble in water but not in benzene because

(a) $\Delta H_{\text{hydration}} < \Delta H_{\text{lattice energy in water}}$ and
$\Delta H_{\text{hydration}} > \Delta H_{\text{lattice energy in benzene}}$

(b) $\Delta H_{\text{hydration}} > \Delta H_{\text{lattice energy in water}}$ and
$\Delta H_{\text{hydration}} < \Delta H_{\text{lattice energy in benzene}}$

(c) $\Delta H_{\text{hydration}} = \Delta H_{\text{lattice energy in water}}$ and
$\Delta H_{\text{hydration}} < \Delta H_{\text{lattice energy in benzene}}$

(d) $\Delta H_{\text{hydration}} < \Delta H_{\text{lattice enery in water}}$ and
$\Delta H_{\text{hydration}} = \Delta H_{\text{lattice energy in benzene}}$

13. During complete combustion of one mole of butane, 2658 kJ of heat is released. The thermochemical reaction for above change is

(a) $2C_4H_{10}(g) + 13O_2(g) \rightarrow 3CO_2(g) + 10H_2O(l)$
$\Delta_r H = -2658.0\,kJ\,mol^{-1}$

(b) $C_4H_{10}(g) + \frac{13}{2}O_2(g) \rightarrow 4CO_2(g) + 5H_2O(l);$
$\Delta_r H = -1129.0\,kJ\,mol^{-1}$

(c) $C_4H_{10}(g) + \frac{13}{2}O_2(g) \rightarrow 4CO_2(g) + 5H_2O(l),$
$\Delta_r H = -2658.0\,kJ\,mol^{-1}$

(d) $C_4H_{10}(g) + \frac{13}{2}O_2(g) \rightarrow 4CO_2(g) + 5H_2O(l);$
$\Delta_r H = +2658.0\,kJ\,mol^{-1}$

14. $\Delta_f U^{\ominus}$ of formation of $CH_4(g)$ at certain temperature is $-393\,kJ\,mol^{-1}$. The value of $\Delta_f H^{\ominus}$ is

(a) Zero (b) $< \Delta_f U^{\ominus}$

(c) $> \Delta_f U^{\ominus}$ (d) Equal to $\Delta_f U^{\ominus}$

15. Enthalpy of sublimation of a substance is equal to

(a) Enthalpy of fusion + enthalpy of vaporisation

(b) Enthalpy of fusion

(c) Enthalpy of vaporisation

(d) Twice the enthalpy of vaporisation

16. The enthalpy of a certain reaction at 273 K is –20.75 kJ. The enthalpy of same reaction at 373 K (if heat capacities of reactants and products is same) will be

(a) –20.75 kJ (b) –2075 kJ

(c) Zero (d) $-20.75 \times \frac{373}{273}\,kJ$

17. The heat of formation is the change in enthalpy accompanying the formation of a substance from its elements at 298 K and 1 atm pressure. Since the enthalpies of elements are taken to be zero, the heat of formation (ΔH) of compounds

(a) Is always negative

(b) Is always positive

(c) May be negative or positive

(d) Is zero

18. The heat of combustion of benzene determined in a bomb calorimeter is $-870\,kcal\,mol^{-1}$ at $25^\circ C$. The value of ΔE for the reaction is

(a) $-1740\,kcal$ (b) $-870\,kcal$

(c) $-872\,kcal$ (d) $-874\,kcal$

19. Which of the following compounds will absorb the maximum quantity of heat when dissolved in the same amount of water ? The heats of solution of these compounds at $25^\circ C$ in $kJ/mole$ of each solute is given in brackets

(a) $HNO_3 (\Delta H = -33)$ (b) $KCl (\Delta H = +17.64)$

(c) $NH_4NO_3 (\Delta H = +25.5)$ (d) $HCl (\Delta H = -74.1)$

20. Which one of the following is always not negative

(a) Enthalpy of combustion

(b) Enthalpy of formation

(c) Enthalpy of neutralisation

(d) Lattice enthalpy

21. Given,

$NH_{3(g)} + 3Cl_{2(g)} \rightleftharpoons NCl_{3(g)} + 3HCl_{(g)}; -\Delta H_1$

$N_{2(g)} + 3H_{2(g)} \rightleftharpoons 2NH_{3(g)}; -\Delta H_2$

$H_{2(g)} + Cl_{2(g)} \rightleftharpoons 2HCl_{(g)}; \Delta H_3$

The heat of formation of $NCl_{3(g)}$ in the terms of $\Delta H_1, \Delta H_2$ and ΔH_3 is

(a) $\Delta H_f = -\Delta H_1 + \frac{\Delta H_2}{2} - \frac{3}{2}\Delta H_3$

(b) $\Delta H_f = \Delta H_1 + \frac{\Delta H_2}{2} - \frac{3}{2}\Delta H_3$

(c) $\Delta H_f = -\Delta H_1 - \frac{\Delta H_2}{2} - \frac{3}{2}\Delta H_3$

(d) None of these

22. The lattice enthalpy and hydration enthalpy of four compounds are given below

Compound	**Lattice enthalpy (in kJ mol^{-1})**	**Hydration enthalpy (in kJ mol^{-1})**
P	+780	– 920
Q	+1012	– 812
R	+828	– 878
S	+632	– 600

The pair of compounds which is soluble in water is

(a) P and Q (b) Q and R

(c) R and S (d) Q and S

(e) P and R

23. The heat liberated when 1.89 g of benzoic acid is burnt in a bomb calorimeter at $25°C$ increases the temperature of 18.94 kg of water by $0.632°C$ .If the specific heat of water at $25°C$ is 0.998 $cal/g\text{-}deg$, the value of the heat combustion of benzoic acid is (in per mole)

(a) 771.1 $kcal$ (b) 871.2 $kcal$

(c) 881.1 $kcal$ (d) 981.1 $kcal$

24. The enthalpies of elements in their standard states are taken as zero. The enthalpy of formation of a compound

(a) Is always negative

(b) Is always positive

(c) May be positive or negative

(d) Is never negative

25. A solution of $500 mL$ of $0.2 M\, KOH$ and $500 mL$ of $0.2 M\, HCl$ is mixed and stirred; the rise in temperature is T_1 . The experiment is repeated using $250 mL$ each of solution, the temperature raised is T_2. Which of the following is true

(a) $T_1 = T_2$ (b) $T_1 = 2T_2$

(c) $T_1 = 4T_2$ (d) $T_2 = 9T_1$

26. The enthalpy of solution of $BaCl_2(s)$ and $BaCl_2.2H_2O(s)$ are -20.6 and $8.8\, kJ\, mol^{-1}$ respectively. The enthalpy change for the reaction $BaCl_2(s) + 2H_2O \rightarrow BaCl_2.2H_2O$ is

(a) 29.4 kJ (b) – 11.8 kJ

(c) – 20.6 kJ (d) – 29.4 kJ

27. When $50\, cm^3$ of a strong acid is added to $50\, cm^3$ of an alkali, the temperature rises by $5°C$. If $250\, cm^3$ of each liquid are mixed, the temperature rise would be

(a) $5°C$ (b) $10°C$

(c) $25°C$ (d) $20°C$

28. Which of the following salt on dissolution in water absorbs heat

(a) NH_4Cl (b) CaO

(c) Na_2SO_4 (d) Na_2CO_3

5. Bond Energy

1. A system is changed from state A to state B by one path and from B to A another path. If E_1 and E_2 are the corresponding changes in internal energy, then

(a) $E_1 + E_2 = -ve$ (b) $E_1 + E_2 = +ve$

(c) $E_1 + E_2 = 0$ (d) None of these

2. If enthalpies of methane and ethane are respectively 320 and 360 calories then the bond energy of $C-C$ bond is

(a) 80 calories (b) 40 calories

(c) 60 calories (d) 120 calories

3. Given the bond energies $N \equiv N$, $H-H$ and $N-H$ bonds are 945, 436 and $391\, kJ\, mole^{-1}$ respectively, the enthalpy of the following reaction $N_2(g) + 3H_2(g) \rightarrow 2NH_3(g)$ is

(a) $-93\, kJ$ (b) $102\, kJ$

(c) $90\, kJ$ (d) $105\, kJ$

4. Enthalpy of formation of HF and HCl are $-161\, kJ$ and $-92\, kJ$ respectively. Which of the following statements is incorrect

(a) HCl is more stable than HF

(b) HF and HCl are exothermic compounds

(c) The affinity of fluorine to hydrogen is greater than the affinity of chlorine to hydrogen

(d) HF is more stable than HCl

5. Which one of the following bonds has the highest average bond energy ($kcal/mol$)

(a) $S = O$ (b) $C \equiv C$

(c) $C \equiv N$ (d) $N \equiv N$

6. Consider the reactions given below. On the basis of these reactions find out which of the algebraic relationship given in options (a) to (d) is correct

(i) $C(g) + 4H(g) \longrightarrow CH_4(g); \Delta_r H = x\, kJ\, mol^{-1}$

(ii) $C(\text{graphite}) + 2H_2(g) \longrightarrow CH_4(g); \Delta_r H = y\, kJ\, mol^{-1}$

(a) $x = y$ (b) $x = 2y$

(c) $x > y$ (d) $x < y$

6. Free Energy and Work Function

1. The reaction, $Zn(s) + CuSO_4(aq) \rightarrow ZnSO_4(aq) + Cu(s)$ is an example for a

(a) Spontaneous process

(b) Non-spontaneous process

(c) Isobaric process

(d) Reversible process

2. The condition of spontaneity of process is

(a) Lowering of entropy at constant temperature and pressure

(b) Lowering of Gibbs free energy of system at constant temperature and pressure

(c) Increase of entropy of system at constant temperature and pressure

(d) Increase of Gibbs free energy of the universe at constant temperature and pressure

3. Mixing of two different ideal gases under isothermal reversible condition will lead to

(a) Increase of Gibbs free energy of the system

(b) No change of entropy of the system

(c) Increase of entropy of the system

(d) Increase of enthalpy of the system

4. For the reaction,

$CaCO_3(s) \rightleftharpoons CaO(s) + CO_2(g)$

partial pressure of CO_2 at 1000 K is 0.003 atm. $\Delta G^\circ = 27.2\,kcal$. Calculate the value of ΔG

(a) 12.6 $kcal$ (b) 15.6 $kcal$

(c) 13.4 $kcal$ (d) 14.2 $kcal$

5. For precipitation reaction of Ag^+ ions with $NaCl$, which of the following statements is correct

(a) ΔH for the reaction is zero

(b) ΔG for the reaction is zero

(c) ΔG for the reaction is negative

(d) $[\Delta G] = [\Delta H]$

6. Identify the correct statement from the following in a chemical reaction

(a) The entropy always increases

(b) The change in entropy along with suitable change in enthalpy decides the fate of a reaction

(c) The enthalpy always decreases

(d) Both the enthalpy and the entropy remain constant

7. As O_2 is cooled at 1 atm pressure, it freezes to form solid I at 54.5 K. At a lower temperature, solid I rearranges to solid II, which has a different crystal structure. Thermal measurements show that for the phase transition solid I to solid II, $\Delta H = -743.1\,J\,mol^{-1}$ and $\Delta S = -17.0\,JK^{-1}\,mol^{-1}$. At what temperature are solids I and II in equilibrium

(a) 2.06 K (b) 31.5 K

(c) 43.7 K (d) 53.4 K

8. Which of the following is not correct

(a) ΔG is zero for a reversible reaction

(b) ΔG is positive for a spontaneous reaction

(c) ΔG is negative for a spontaneous reaction

(d) ΔG is positive for a non-spontaneous reaction

9. Thermodynamically the most stable form of carbon is

(a) Diamond (b) Graphite

(c) Fullerenes (d) Coal

7. IIT-JEE/ AIEEE

1. Assuming that water vapour is an ideal gas, the internal energy (ΔU) when 1 mol of water is vapourised at 1 bar pressure and 100°C, (Given : Molar enthalpy of vapourization of water at 1 bar and 373 K = 41 $kJ\,mol^{-1}$ and $R = 8.3\,J\,mol^{-1}K^{-1}$) will be **[2007]**

(a) 4.100 $kJ\,mol^{-1}$ (b) 3.7904 $kJ\,mol^{-1}$

(c) 37.904 $kJ\,mol^{-1}$ (d) 41.00 $kJ\,mol^{-1}$

2. Consider the reaction : $N_2 + 3H_2 \rightarrow 2NH_3$ carried out at constant temperature and pressure. If ΔH and ΔU are the enthalpy and internal energy changes for the reaction, which of the following expression is true **[2005]**

(a) $\Delta H = 0$ (b) $\Delta H = \Delta U$

(c) $\Delta H < \Delta U$ (d) $\Delta H > \Delta U$

3. The heat required to raise the temperature of a body by 1 K is called **[2002]**

(a) Specific heat (b) Thermal capacity

(c) Water equivalent (d) None of these

4. For which one of the following reactions, ΔH is not equal to ΔE **[1995]**

(a) $H_{2(g)} + I_{2(g)} \rightleftharpoons 2HI_{(g)}$

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

(c) $N_{2(g)} + 3H_{2(g)} \rightleftharpoons 2NH_{3(g)}$

(d) $HCl_{(aq)} + NaOH_{(aq)} \rightleftharpoons NaCl_{(aq)} + H_2O$

5. For the reaction, $2CO + O_2 \rightarrow 2CO_2; \Delta H = 560 kJ$. Two moles of CO and one mole of O_2 are taken in a container of volume $1L$. They completely form two moles of CO_2, the gases deviate appreciably from ideal behaviour. If the pressure in the vessel changes from 70 to 40 atm, find the magnitude (absolute value) of ΔU at $500\,K$ ($1\,L$ atm = $0.1\,kJ$)

(a) 563 (b) 575

(c) 585 (d) 595

6. $(\Delta H - \Delta U)$ for the formation of carbon monoxide (CO) from its elements at 298 K is $(R = 8.314\, JK^{-1} mol^{-1})$ **[2006]**

(a) $-1238.78\, J\, mol^{-1}$ (b) $1238.78\, J\, mol^{-1}$

(c) $-2477.57\, J\, mol^{-1}$ (d) $2477.57\, J\, mol^{-1}$

7. A piston filled with $0.04\, mol$ of an ideal gas expands reversibly from $50.0\, mL$ to $375\, mL$ at a constant temperature of 37.0°C. As it does so, it absorbs 208 J of heat. The values of q and w for the process will be **[2013]**

(R = 8.314 $J/mol\, K$) (ln 7.5 = 2.01)

(a) $q = +208 J, w = -208 J$ (b) $q = -208 J, w = -208 J$

(c) $q = -208 J, w = +208 J$ (d) $q = +208 J, w = +208 J$

8. The enthalpy change for the following processes are listed below

$Cl_2(g) = 2Cl(g)$,	$242.3\, kJ\, mol^{-1}$
$I_2(g) = 2I(g)$,	$151.0\, kJ\, mol^{-1}$
$ICl(g) = I(g) + Cl(g)$,	$211.3\, kJ\, mol^{-1}$
$I_2(s) = I_2(g)$,	$62.76\, kJ\, mol^{-1}$

Given that the standard states for iodine and chlorine are I_2 (s) and $Cl_2(g)$, the standard enthalpy of formation for $ICl(g)$ is **[2006]**

(a) $-14.6\, kJ\, mol^{-1}$ (b) $-16.8\, kJ\, mol^{-1}$

(c) $+16.8\, kJ\, mol^{-1}$ (d) $+244.8\, kJ\, mol^{-1}$

9. Molar heat capacity of water in equilibrium with ice at constant pressure is **[1997]**

(a) Zero (b) Infinity (∞)

(c) $40.45\, kJ\, K^{-1} mol^{-1}$ (d) $75.48\, J\, K^{-1}$

10. The enthalpies of combustion of carbon and carbon monoxide are –393.5 and –283 $kJ\ mol^{-1}$ respectively. The enthalpy of formation of carbon monoxide per mole is **[2004; 2016]**

(a) $-676.5\, kJ$ (b) $676.5\, kJ$

(c) $110.5\, kJ$ (d) $-110.5\, kJ$

11. An ideal gas expands in volume from $1 \times 10^{-3} m^3$ to $1 \times 10^{-2} m^3$ at 300 K against a constant pressure of $1 \times 10^5 Nm^{-2}$. The work done is **[2004]**

(a) 270 kJ (b) –900 kJ

(c) –900 J (d) 900 kJ

12. An ideal gas is allowed to expand both reversibly and irreversibly in an isolated system. If T_i is the initial temperature and T_f is the final temperature, which of the following statements is correct **[2006]**

(a) $(T_f)_{\text{irrev}} > (T_f)_{\text{rev}}$

(b) $T_f > T_i$ for reversible process but $T_f = T_i$ for irreversible process

(c) $(T_f)_{\text{rev}} = (T_f)_{\text{irrev}}$

(d) $T_f = T_i$ for both reversible and irreversible processes

13. Two mole of an ideal gas is expanded isothermally and reversibly from 1 litre to 10 litre at $300K$. The enthalpy change (in kJ) for the process is **[2004]**

(a) 11.4 kJ (b) –11.4 kJ

(c) 0 kJ (d) 4.8 kJ

14. When one mole of monoatomic ideal gas at T K undergoes adiabatic change under a constant external pressure of 1 atm changes volume from 1 litre to 2 litre. The final temperature in Kelvin would be **[2005]**

(a) $\dfrac{T}{2^{(2/3)}}$ (b) $T + \dfrac{2}{3 \times 0.0821}$

(c) T (d) $T - \dfrac{2}{3 \times 0.0821}$

15. ΔU equal to **[2017]**

(a) Isobaric work (b) Adiabatic work

(c) Isothermal work (d) Isochoric work

16. The combustion of benzene (l) gives $CO_2(g)$ and $H_2O(l)$. Given that heat of combustion of benzene at constant volume is -3263.9 kJ mol^{-1} at $25°C$; heat of combustion (in kJ mol^{-1}) of benzene at constant pressure will be

(R = 8.314 JK^{-1} mol^{-1}) **[2018]**

(a) 3260 (b) – 3267.6

(c) 4152.6 (d) – 452.46

17. A heat engine absorbs heat Q_1 at temperature T_1 and heat Q_2 at temperature T_2. Work done by the engine is $(Q_1 + Q_2)$. This data **[2002]**

(a) Violates Ist law of thermodynamics

(b) Violates Ist law of thermodynamics if Q_1 is $-ve$

(c) Violates Ist law of thermodynamics if Q_2 is $-ve$

(d) Does not violate Ist law of thermodynamics

18. The enthalpy of vaporization of a liquid is $30\,kJ\,mol^{-1}$ and entropy of vaporization is $75\,J\,mol^{-1}K$. The boiling point of the liquid at 1 atm is **[2004]**

(a) $250K$ (b) $400K$

(c) $450K$ (d) $600K$

19. The direct conversion of A to B is difficult, hence it is carried out by the following shown path

$$\begin{tikzcd} C \arrow[r] & D \arrow[d] \\ A \arrow[u] & B \end{tikzcd}$$

Given $\Delta S_{(A\to C)} = 50\,e.u.$

$\Delta S_{(C\to D)} = 30\,e.u.$

$\Delta S_{(B\to D)} = 20\,e.u.$

where e.u. is entropy unit then $\Delta S_{(A\to B)}$ is **[2006]**

(a) + 100 e.u. (b) + 60 e.u.

(c) – 100 e.u. (d) – 60 e.u.

20. The entropy change involved in the isothermal reversible expansion of 2 moles of an ideal gas from a volume of $10\,dm^3$ to a volume of $100\,dm^3$ at $27°C$ is **[2011]**

(a) $38.3\,J\,mol^{-1}K^{-1}$ (b) $35.8\,J\,mol^{-1}K^{-1}$

(c) $32.3\,J\,mol^{-1}K^{-1}$ (d) $42.3\,J\,mol^{-1}K^{-1}$

21. The difference between heats of reaction at constant pressure and at constant volume for the reaction $2C_6H_6(l) + 15O_2(g) \rightarrow 12CO_2(g) + 6H_2O(l)$ at $25°C$ in kJ is **[1991]**

(a) –7.43 (b) +3.72

(c) –3.72 (d) +7.43

22. Which of the following equations correctly represents the standard heat of formation (ΔH_f^o) of methane **[1992]**

(a) $C(diamond) + 2H_2(g) \rightarrow CH_4(g)$

(b) $C(graphite) + 2H_2(g) \rightarrow CH_4(l)$

(c) $C(graphite) + 2H_2(g) \rightarrow CH_4(g)$

(d) $C(graphite) + 4H \rightarrow CH_4(g)$

23. Standard molar enthalpy of formation of CO_2 is equal to **[1997]**

(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)

24. The ΔH_f^o for $CO_2(g), CO(g)$ and $H_2O(g)$ are – 393.5, – 110.5 and – 241.8$kJmol^{-1}$ respectively. The standard enthalpy change (in kJ) for the reaction $CO_2(g) + H_2(g) \rightarrow CO(g) + H_2O(g)$ is **[2000]**

(a) 524.1 (b) 41.2

(c) – 262.5 (d) – 41.2

25. Which of the reaction defines ΔH_f^o **[2003]**

(a) $C_{(diamond)} + O_2(g) \rightarrow CO_2(g)$

(b) $\frac{1}{2}H_2(g) + \frac{1}{2}F_2(g) \rightarrow HF(g)$

(c) $N_2(g) + 3H_2(g) \rightarrow 2NH_3(g)$

(d) $CO(g) + \frac{1}{2}O_2(g) \rightarrow CO_2(g)$

26. The species which by definition has **ZERO** standard molar enthalpy of formation at 298 K is **[2010]**

(a) $Br_2(g)$ (b) $Cl_2(g)$

(c) $H_2O(g)$ (d) $CH_4(g)$

27. The standard molar heat of formation of ethane, CO_2 and water (l) are respectively – 21.1, – 94.1 and – 68.3 $kcal$. The standard molar heat of combustion of ethane will be **[1986]**

(a) – 372 $kcal$ (b) 162 $kcal$

(c) – 240 $kcal$ (d) 183.5 $kcal$

28. Which of the following is an endothermic reaction **[1989]**

(a) $2H_2 + O_2 \rightarrow 2H_2O$

(b) $N_2 + O_2 \rightarrow 2NO$

(c) $2NaOH + H_2SO_4 \rightarrow Na_2SO_4 + 2H_2O$

(d) $3O_2 + C_2H_5OH \rightarrow 2CO_2 + 3H_2O$

29. The standard enthalpies of formation of $CO_2(g)$, $H_2O(l)$ and glucose(s) at $25°C$ are $-400\,kJ/mol$, $-300\,kJ/mol$ and $-1300\,kJ/mol$, respectively. The standard enthalpy of combustion per gram of glucose at $25°C$ is **[2013]**

(a) $+2900\,kJ$ (b) $-2900\,kJ$

(c) $-16.11\,kJ$ (d) $+16.11\,kJ$

30. On the basis of the following thermochemical data : $(\Delta_f G^{o} H^{+}_{(aq)} = 0)$

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

$$H_{2(g)} + \frac{1}{2}O_{2(g)} \rightarrow H_2O_{(l)};\ \Delta H = -286.20\,kJ$$

The value of enthalpy of formation of OH^- ion at 25°C is **[2009]**

(a) $-22.88\,kJ$ (b) $-228.88\,kJ$

(c) $+228.88\,kJ$ (d) $-343.52\,kJ$

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

$$\frac{1}{2}Cl_2(g) \xrightarrow{\frac{1}{2}\Delta_{diss}\overset{\ominus}{H}} Cl(g) \xrightarrow{\Delta_{eg}\overset{\ominus}{H}} Cl^-(g) \xrightarrow{\Delta_{hyd}\overset{\ominus}{H}} Cl^-(aq)$$

The energy involved in the conversion of

$\frac{1}{2}Cl_2(g)$ to $Cl^-(aq)$

(Using the data,

$\Delta_{diss}\overset{\ominus}{H}_{Cl_2} = 240 kJmol^{-1}$,

$\Delta_{eg}\overset{\ominus}{H}_{Cl} = -349 kJmol^{-1}$,

$\Delta_{hyd}\overset{\ominus}{H}_{Cl} = -381 kJmol^{-1}$) will be **[2008]**

(a) $-610\,kJ\,mol^{-1}$ (b) $-850\,kJ\,mol^{-1}$

(c) $+120\,kJ\,mol^{-1}$ (d) $+152\,kJ\,mol^{-1}$

32. For complete combustion of ethanol, $C_2H_5OH(l) + 3O_2(g) \rightarrow 2CO_2(g) + 3H_2O(l)$, the amount of heat produced as measured in bomb calorimeter, is $1364.47\,kJ\,mol^{-1}$ at $25°C$. Assuming ideality the Enthalpy of combustion. $\Delta_C H$, for the reaction will be $(R = 8.314\,kJ\,mol^{-1})$

[2014]

(a) $-1366.95\,kJ\,mol^{-1}$ (b) $-1361.95\,kJ\,mol^{-1}$

(c) $-1460.50\,kJ\,mol^{-1}$ (d) $-1350.50\,kJ\,mol^{-1}$

33. For an endothermic reaction where ΔH represents the enthalpy of the reaction in *kJ/mole*, the minimum value for the energy of activation will be **[1992]**

(a) Less than ΔH (b) Zero

(c) More than ΔH (d) Equal to ΔH

34. Given

$$C_{(graphite)} + O_2(g) \rightarrow CO_2(g); \Delta_r H^{o} = -393.5\,kJ\,mol^{-1};$$

$$H_2(g) + \frac{1}{2}O_2(g) \rightarrow H_2O(l); \Delta_r H^{o} = -285.8\,kJ\,mol^{-1};$$

$$CO_2(g) + 2H_2O(l) \rightarrow CH_4(g) + 2O_2(g); \Delta_r H^{o} = +890.3\,kJ\,mol^{-1}$$

Based on the above thermochemical equations, the value of $\Delta_r H^{o}$ at 298 K for the reaction

$C_{(graphite)} + 2H_2(g) \rightarrow CH_4(g)$ will be **[2017]**

(a) $+144.0\,kJ\,mol^{-1}$ (b) $-74.8\,kJ\,mol^{-1}$

(c) $-144.0\,kJ\,mol^{-1}$ (d) $+74.8\,kJ\,mol^{-1}$

35. The bond dissociation energy needed to form benzyl radical from toluene is ..... than the formation of the methyl radical from methane **[1994]**

(a) Less (b) More

(c) Equal (d) None of the above

36. The standard enthalpy of formation of NH_3 is $-46.0 kJ\,mol^{1-}$. If the enthalpy of formation of H_2 from its atoms is $-436 kJ\,mol^{-1}$ and that of N_2 is $-712 kJ\,mol^{-1}$, the average bond enthalpy of $N-H$ bond in NH_3 is

[2010]

(a) $-1102\,kJ\,mol^{-1}$ (b) $-964\,kJ\,mol^{-1}$

(c) $+352\,kJ\,mol^{-1}$ (d) $+1056\,kJ\,mol^{-1}$

37. The bond energy (in *kcal mol*$^{-1}$) of a $C-C$ single bond is approximately **[2010]**

(a) 1 (b) 10

(c) 100 (d) 1000

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

$$2C(s) + H_2(g) \longrightarrow C_2H_2(g) \qquad \Delta H = 225 kJ\,mol^{-1}$$

$$2C(s) \longrightarrow 2C(g) \qquad \Delta H = 1410 kJ\,mol^{-1}$$

$$H_2(g) \longrightarrow 2H(g) \qquad \Delta H = 330 kJ\,mol^{-1}$$

[2012]

(a) 1165 (b) 837

(c) 865 (d) 815

39. The standard enthalpy of formation ($\Delta H_f{}^\circ$) at 298 K for methane, $CH_4(g)$, is – 74.8 kJ mol^{-1} The additional information required to determine the average energy for C-H bond formation would be **[2006]**

(a) The dissociation energy of H_2 and enthalpy of sublimation of carbon

(b) Latent heat of vapourization of methane

(c) The first four ionization energies of carbon and electron gain enthalpy of hydrogen

(d) The dissociation energy of hydrogen molecule, H_2

40. If an endothermic reaction is non-spontaneous at freezing point of water and becomes feasible at its boiling point then **[2002]**

(a) ΔH is $-ve$, ΔS is $+ve$

(b) ΔH and ΔS both are + ve

(c) ΔH and ΔS both are – ve

(d) ΔH is + ve, ΔS is – ve

41. For the process $H_2O(l)$ (1 bar, 373 K) $\longrightarrow$ $H_2O(g)$ (1 bar, 373 K), the correct set of thermodynamic parameters is **[2007]**

(a) $\Delta G = 0, \Delta S = +ve$ (b) $\Delta G = 0, \Delta S = -ve$

(c) $\Delta G = +ve, \Delta S = 0$ (d) $\Delta G = -ve, \Delta S = +ve$

42. The value of $\log_{10} K$ for a reaction $A \rightleftharpoons B$ is

(Given : $\Delta_r H^\circ_{298K} = -54.07 kJ\, mol^{-1}$,

$\Delta_r S^\circ_{298K} = 10 JK^{-1}mol^{-1}$ and $R = 8.314\, JK^{-1}mol^{-1}; 2.303 \times 8.314 \times 298 = 5705$) **[2007]**

(a) 5 (b) 10

(c) 95 (d) 100

43. 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 change in entropy (dS), satisfy the criteria **[2003]**

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

44. For a particular reversible reaction at temperature $T, \Delta H$ and ΔS were found to be both $+ve$. If the temperature T_e is at equilibrium, the reaction would be spontaneous when **[2010]**

(a) $T = T_e$ (b) $T_e > T$

(c) $T > T_e$ (d) T_e is 5 time T

45. Adsorption of gases on solid surface is generally exothermic because **[2004]**

(a) Enthalpy is positive (b) Entropy decreases

(c) Entropy increases (d) Free energy increase

46. The incorrect expression among the following is **[2012]**

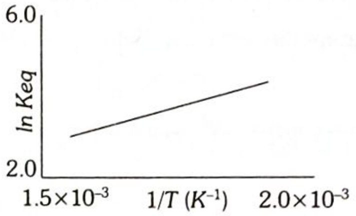
(a) $\dfrac{\Delta G_{system}}{\Delta S_{total}} = -T$

(b) In isothermal process, $W_{reversible} = -nRT \ln \dfrac{V_f}{V_i}$

(c) $\ln K = \dfrac{\Delta H^o - T\Delta S^o}{RT}$

(d) $K = e^{-\Delta G^o/RT}$

47. A schematic plot of lnK_{eq} versus inverse of temperature for a reaction is shown below



The reaction must be **[2005]**

(a) Exothermic

(b) Endothermic

(c) One with negligible enthalpy change

(d) Highly spontaneous at ordinary temperature

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

$$CH_3OH(l) + \frac{3}{2}O_2(g) \rightarrow CO_2(g) + 2H_2O(l)$$

At 298K standard Gibb's energies of formation for $CH_3OH(l), H_2O(l)$ and $CO_2(g)$ are –166.2, –237.2 and –394.4 kJ mol^{-1} respectively. If standard enthalpy of combustion of methanol is $-726\, kJ\, mol^{-1}$, efficiency of the fuel cell will be **[2009]**

(a) 80% (b) 87%

(c) 90% (d) 97%

49. The following reaction is performed at 298 K.

$$2NO(g) + O_2(g) \rightleftharpoons 2NO_2(g)$$

The standard free energy of formation of $NO(g)$ is $86.6\, kJ/mol$ at 298 K. What is the standard free energy of formation of $NO_2(g)$ at 298 K ($K_p = 1.6 \times 10^{12}$) **[2015]**

(a) $R(298)\ln(1.6 \times 10^{12}) - 86600$

(b) $86600 + R(298)\ln(1.6 \times 10^{12})$

(c) $86600 - \dfrac{\ln(1.6 \times 10^{12})}{R(298)}$

(d) $0.5[2 \times 86600 - R(298)\ln(1.6 \times 10^{12})]$

50. The standard Gibbs energy change at 300 K for the reaction $2A \rightleftharpoons B+C$ is 2494.2 J. At a given time, the composition of the reaction mixture is $[A]=\frac{1}{2}, [B]=2$ and $[C]=\frac{1}{2}$. The reaction proceeds in the $[R = 8.314\ J/K/mol, e = 2.718]$ **[2015]**

(a) Forward direction because $Q > K_C$

(b) Reverse direction because $Q > K_C$

(c) Forward direction because $Q < K_C$

(d) Reverse direction because $Q < K_C$

8. NEET/ AIPMT/ CBSE-PMT

1. Which of the following are not state functions

(I) $q + w$ (II) q

(III) w (IV) $H - TS$

[2008]

(a) (I), (II) and (III) (b) (II) and (III)

(c) (I) and (IV) (d) (II), (III) and (IV)

2. The internal energy change when a system goes from state A to B is 40 kJ/mole. 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

[2003]

(a) 40 kJ (b) > 0 kJ

(c) < 40 kJ (d) Zero

3. For the reaction $N_2 + 3H_2 \rightleftharpoons 2NH_3; \Delta H =$

[1991, 2002]

(a) $\Delta E - RT$ (b) $\Delta E - 2RT$

(c) $\Delta E + RT$ (d) $\Delta E + 2RT$

4. If ΔH is the change in enthalpy and ΔE the change in internal energy accompanying a gaseous reaction **[1990]**

(a) ΔH is always greater than ΔE

(b) $\Delta H < \Delta E$ only if the number of moles of the products is greater than the number of the reactants

(c) ΔH is always less than ΔE

(d) $\Delta H < \Delta E$ only if the number of moles of the products is less than the number of moles of the reactants

5. During an isothermal expansion of an ideal gas its **[1991]**

(a) Internal energy increases

(b) Enthalpy decreases

(c) Enthalpy remains unaffected

(d) Enthalpy reduces to zero

6. Which of the following expressions represents the first law of thermodynamics **[2000]**

(a) $\Delta E = -q + W$ (b) $\Delta E = q - W$

(c) $\Delta E = q + W$ (d) $\Delta E = -q - W$

7. In a closed insulated container, a liquid is stirred with a paddle to increase its temperature. In this process, which of the following is true **[2002]**

(a) $\Delta E = W = Q = 0$ (b) $\Delta E \neq 0, Q = W = 0$

(c) $\Delta E = W \neq 0, Q = 0$ (d) $\Delta E = Q \neq 0, W = 0$

8. For the reaction,

$C_3H_8(g) + 5O_2(g) \rightarrow 3CO_2(g) + 4H_2O(l)$

at constant temperature, $\Delta H - \Delta E$ is **[2003]**

(a) $-RT$ (b) $+RT$

(c) $-3RT$ (d) $+3RT$

9. The molar heat capacity of water at constant pressure is $75\ JK^{-1}mol^{-1}$. When 1.0 kJ of heat is supplied to 100 g of water which is free to expand, the increase in temperature of water is **[2003]**

(a) 6.6 K (b) 1.2 K

(c) 2.4 K (d) 4.8 K

10. Standard enthalpy of vapourisation $\Delta_{vap}H^0$ for water at 100°C is 40.66 $kJ\ mol^{-1}$. The internal energy of vaporization of water at 100°C (in $kJ\ mol^{-1}$) is **[2012]**

(a) + 37.56 (b) – 43.76

(c) + 43.76 (d) + 40.66

11. Equal volumes of two monoatomic gases, A and B, at same temperature and pressure are mixed. The ratio of specific heats (C_p/C_v) of the mixture will be **[2012]**

(a) 0.83 (b) 1.50

(c) 3.3 (d) 1.67

12. Which of the following is the correct equation **[1996]**

(a) $\Delta U = Q - W$ (b) $W = \Delta U + Q$

(c) $\Delta U = W + Q$ (d) None of these

13. Consider the following processes **[2011]**

	$\Delta H (kJ/mol)$
$1/2\, A \rightarrow B$	+150
$3B \rightarrow 2C + D$	–125
$E + A \rightarrow 2D$	+350

For $B + D \rightarrow E + 2C, \Delta H$ Will be

(a) –325kJ/mol (b) 325kJ/mol

(c) 525kJ/mol (d) –175kJ/mol

14. One mole of an ideal gas at $300K$ is expanded isothermally from an initial volume of 1 litre to 10 litres. The change in energy for this process is $(R = 2\,cal\,mol^{-1}K^{-1})$ **[1998]**

(a) 163.7 *cal*
(b) 850.2 *cal*
(c) 1381.1 *cal*
(d) Zero

15. Two moles of an ideal gas expand spontaneously into a vacuum. The work done is **[2010]**

(a) 2 *Joule*
(b) 4 *Joule*
(c) Zero
(d) Infinite

16. A gas is allowed to expand in a well insulated container against a constant external pressure of 2.5 *atm* from an initial volume of 2.50 *L* to a final volume of 4.50 *L*. The change in internal energy ΔU of the gas in joules will be **[2017]**

(a) 1136.25 J
(b) –500 J
(c) –505 J
(d) +505 J

17. Identify the correct statement regarding entropy **[1998]**

(a) At 0^oC, the entropy of a perfectly crystalline substance is taken to be zero
(b) At absolute zero of temperature, the entropy of a perfectly crystalline substance is $+ve$
(c) At absolute zero of temperature, the entropy of all crystalline substances is taken to be zero
(d) At absolute zero of temperature, the entropy of a perfectly crystalline substance is taken to be zero

18. The unit of entropy is **[2002]**

(a) $J\,mol^{-1}$
(b) $JK\,mol^{-1}$
(c) $J\,mol^{-1}K^{-1}$
(d) $J^{-1}K^{-1}mol^{1}$

19. For a sample of perfect gas when its pressure is changed isothermally from p_i to p_f, the entropy change is given by **[2016]**

(a) $\Delta S = RT\ln\left(\frac{p_i}{p_f}\right)$
(b) $\Delta S = nR\ln\left(\frac{p_f}{p_i}\right)$
(c) $\Delta S = nR\ln\left(\frac{p_i}{p_f}\right)$
(d) $\Delta S = nRT\ln\left(\frac{p_f}{p_i}\right)$

20. Which of the following statements is correct for the spontaneous adsorption of a gas **[1995, 2014]**

(a) ΔS is positive and, therefore, ΔH should be negative
(b) ΔS is positive and, therefore, ΔH should also be highly positive
(c) ΔS is negative and, therefore, ΔH should be highly positive
(d) ΔS is negative and therefore, ΔH should be highly negative

21. For the gas phase reaction s

$$PCl_5(g) \rightleftharpoons PCl_3(g) + Cl_2(g)$$

Which of the following conditions are correct **[2008]**

(a) $\Delta H < 0$ 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 $\Delta S > 0$

22. Considering entropy (S) as a thermodynamic parameter, the criterion for the spontaneity of any process is **[2004]**

(a) $\Delta S_{system} > 0$ only
(b) $\Delta S_{surroundings} > 0$ only
(c) $\Delta S_{system} + \Delta S_{surroundings} > 0$
(d) $\Delta S_{system} - \Delta S_{surroundings} > 0$

23. Based on the following thermochemical equations

$$H_2O(g) + C(s) \rightarrow CO(g) + H_2(g);\ \Delta H = 131\,kJ$$

$$CO(g) + \frac{1}{2}O_2(g) \rightarrow CO_2(g);\ \Delta H = -282\,kJ$$

$$H_2(g) + \frac{1}{2}O_2(g) \rightarrow H_2O(g);\ \Delta H = -242\,kJ$$

$$C(s) + O_2(g) \rightarrow CO_2(g);\ \Delta H = X\,kJ$$

The value of X is **[1992]**

(a) $-393\,kJ$
(b) $-655\,kJ$
(c) $+393\,kJ$
(d) $+655\,kJ$

24. For which one of the following equations is ΔH^o_{react} equal to ΔH^o_f for the product **[2003]**

(a) $2CO(g) + O_2(g) \rightarrow 2CO_2(g)$
(b) $N_2(g) + O_3(g) \rightarrow N_2O_3(g)$
(c) $CH_4(g) + 2Cl_2(g) \rightarrow CH_2Cl_2(l) + 2HCl(g)$
(d) $Xe(g) + 2F_2(g) \rightarrow XeF_4(g)$

25. The heat of combustion of carbon to CO_2 is $-393.5\,kJ/mol$. The heat released upon formation of 35.2 g of CO_2 from carbon and oxygen gas is **[2015]**

(a) $+315\,kJ$
(b) $-31.5\,kJ$
(c) $-315\,kJ$
(d) $+31.5\,kJ$

26. For a hypothetic reaction $A \rightarrow B$, the activation energies for forward and backward reactions are 19 *kJ/mole* and 9 *kJ/mole* respectively. The heat of reaction is **[2000]**

(a) 28 *kJ*
(b) 19 *kJ*
(c) 10 *kJ*
(d) 9 *kJ*

27. Enthalpy of formation of two compounds x and y are $-84\ kJ$ and $-156\ kJ$ respectively. Which of the following statements is correct **[2001]**

(a) x is more stable than y

(b) x is less stable than y

(c) Both x and y are unstable

(d) x and y are endothermic compounds

28. The absolute enthalpy of neutralisation of the reaction $MgO(s) + 2HCl(aq) \rightarrow MgCl_2(aq) + H_2O(l)$ will be **[2005]**

(a) Less than $-57.33\ kJ\ mol^{-1}$

(b) $-57.33\ kJ\ mol^{-1}$

(c) Greater than $-57.33\ kJ\ mol^{-1}$

(d) $57.33\ kJ\ mol^{-1}$

29. The following two reactions are known

$Fe_2O_3(s) + 3CO(g) \rightarrow 2Fe(s) + 3CO_2(g); \Delta H = -26.8\ kJ$

$FeO(s) + CO(g) \rightarrow Fe(s) + CO_2(g); \Delta H = -16.5\ kJ$

The value of ΔH for the following reaction

$Fe_2O_3(s) + CO(g) \rightarrow 2FeO(s) + CO_2(g)$ is **[2010]**

(a) $+10.3\ kJ$ (b) $-43.3\ kJ$

(c) $-10.3\ kJ$ (d) $+6.2\ kJ$

30. Bond dissociation enthalpy of H_2, Cl_2 and HCl are 434, 242 and 431 $kJmol^{-1}$ respectively. Enthalpy of formation of HCl is **[2008]**

(a) $-93 kJmol^{-1}$ (b) $245 kJmol^{-1}$

(c) $93 kJmol^{-1}$ (d) $-245 kJmol^{-1}$

31. If the bond energies of $H-H$, $Br-Br$ and HBr are 433, 192 and 364 $kJ\ mol^{-1}$ respectively, the ΔH^{o} for the reaction, $H_2(g) + Br_2(g) \rightarrow 2HBr(g)$ is **[2004]**

(a) $+261\ kJ$ (b) $-103\ kJ$

(c) $-261\ kJ$ (d) $+103\ kJ$

32. Enthalpy change for the reaction, $4H_{(g)} \rightarrow 2H_{2(g)}$ is $-869.6 kJ$. The dissociation energy of $H-H$ bond is **[2011]**

(a) + 217.4 kJ (b) – 434.8 kJ

(c) – 869.6 kJ (d) + 434.8 kJ

33. If the bond dissociation energies of XY, X_2 and Y_2 (all diatomic molecules) are in the ratio of 1 : 1 : 0.5 and $\Delta_f H$ for the formation of XY is $-200\ kJ\ mole^{-1}$. The bond dissociation energy of X_2 will be **[2005; 2018]**

(a) $100\ kJ\ mol^{-1}$ (b) $800\ kJ\ mol^{-1}$

(c) $300\ kJ\ mol^{-1}$ (d) $400\ kJ\ mol^{-1}$

34. From the following bond energies :

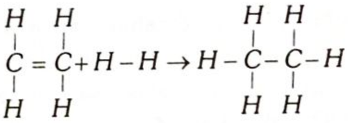
$H-H$ bond energy : 431.37 $kJ\ mol^{-1}$

$C=C$ bond energy : 606.10 $kJ\ mol^{-1}$

$C-C$ bond energy : 336.49 $kJ\ mol^{-1}$

$C-H$ bond energy : 410.50 $kJ\ mol^{-1}$

Enthalpy for the reaction,



$H_2C=CH_2 + H-H \rightarrow H_3C-CH_3$

will be **[2003; 2009]**

(a) 1523.6 $kJ\ mol^{-1}$ (b) –243.6 $kJ\ mol^{-1}$

(c) –120.0 $kJ\ mol^{-1}$ (d) 553.0 $kJ\ mol^{-1}$

35. Given that bond energies of $H-H$ and $Cl-Cl$ are 430 $kJ\ mol^{-1}$ and 240 $kJ\ mol^{-1}$ respectively and $\Delta_f H$ for HCl is $-90 kJ\ mol^{-1}$. Bond enthalpy of HCl is **[2007]**

(a) $290 kJ\ mol^{-1}$ (b) $380 kJ\ mol^{-1}$

(c) $425 kJ\ mol^{-1}$ (d) $245 kJ\ mol^{-1}$

36. The values of ΔH and ΔS for the reaction, $C_{(graphite)} + CO_{2(g)} \rightarrow 2CO_{(g)}$ are 170 kJ and 170 JK^{-1}, respectively. This reaction will be spontaneous at **[2009]**

(a) 710 K (b) 910 K

(c) 1110 K (d) 510 K

37. Which of the following pairs of a chemical reaction is certain to result in spontaneous reaction **[2005]**

(a) Exothermic and decreasing disorder

(b) Endothermic and increasing disorder

(c) Exothermic and increasing disorder

(d) Endothermic and decreasing disorder

38. The enthalpy and entropy change for the reaction

$Br_2(l) + Cl_2(g) \rightarrow 2BrCl(g)$ are $30 kJ\ mol^{-1}$ and 105 JK^{-1} mol^{-1} respectively. The temperature at which the reaction will be in equilibrium is **[2006]**

(a) 450 K (b) 300 K

(c) 285.7 K (d) 273 K

39. Standard enthalpy and standard entropy changes for the oxidation of ammonia at 298 K are $-382.64\ kJ\ mol^{-1}$ and $-145.6\ JK^{-1}mol^{-1}$, respectively. Standard Gibbs energy change for the same reaction at 298 K is **[2004]**

(a) $-439.3\ kJ\ mol^{-1}$ (b) $-523.2\ kJ\ mol^{-1}$

(c) $-221.1\ kJ\ mol^{-1}$ (d) $-339.3\ kJ\ mol^{-1}$

40. When enthalpy and entropy change for a chemical reaction are $-2.5\times10^3\,cal$ and $7.4\,cal\ \deg^{-1}$ respectively. Predict the reaction at $298\,K$ is **[2000]**

(a) Spontaneous (b) Reversible

(c) Irreversible (d) Non-spontaneous

41. For vaporization of water at 1 atmospheric pressure, the values of ΔH and ΔS are 40.63 $kJ\ mol^{-1}$ and 108.8 $JK^{-1}\,mol^{-1}$, respectively. The temperature when Gibbs energy change (ΔG) for this transformation will be zero, is **[2010]**

(a) 273.4 K (b) 393.4 K

(c) 373.4 K (d) 293.4 K

42. Using the Gibbs energy change, $\Delta G^o = +63.3kJ$, for the following reaction, $Ag_2CO_3(s) \rightleftharpoons 2Ag^+(aq) + CO_3^{2-}(aq)$ the K_{sp} of $Ag_2CO_3(s)$ in water at $25°C$ is $(R = 8.314\,J\,K^{-1}\,mol^{-1})$ **[2014]**

(a) 2.9×10^{-3} (b) 7.9×10^{-2}

(c) 3.2×10^{-26} (d) 8.0×10^{-12}

43. For the reaction, $X_2O_4(l) \longrightarrow 2XO_2(g)$ $\Delta U = 2.1\,kcal$, $\Delta S = 20\,cal\,K^{-1}$ at $300\,K$ Hence, ΔG is **[2014]**

(a) 9.3 $kcal$ (b) –9.3 $kcal$

(c) 2.7 $kcal$ (d) –2.7 $kcal$

44. Which of the following statements is correct for a reversible process in a state of equilibrium **[2015]**

(a) $\Delta G = 2.30\,RT\log K$ (b) $\Delta G^o = -2.30\,RT\log K$

(c) $\Delta G^o = 2.30\,RT\log K$ (d) $\Delta G = -2.30\,RT\log K$

45. The correct thermodynamic conditions for the spontaneous reaction at all temperatures is **[2016]**

(a) $\Delta H < 0$ 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 $\Delta S < 0$

46. A reaction occurs spontaneously if **[2005]**

(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 are +ve

(d) $T\Delta S > \Delta H$ and ΔH is +ve and ΔS is –ve

47. Standard entropy of X_2, Y_2 and XY_3 are 60, 40 and 50 $JK^{-1}mol^{-1}$, 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 **[2010]**

(a) 500 K (b) 750 K

(c) 1000 K (d) 1250 K

48. In which of the following reactions, standard reaction entropy change (ΔS^o) is positive and standard Gibb's energy change (ΔG^o) decreases sharply with increasing temperature **[2012]**

(a) C graphite $+\frac{1}{2}O_2(g) \rightarrow CO(g)$

(b) $CO(g) + \frac{1}{2}O_2(g) \rightarrow CO_2(g)$

(c) $Mg(s) + \frac{1}{2}O_2(g) \rightarrow MgO(s)$

(d) $\frac{1}{2}C$ graphite $+\frac{1}{2}O_2(g) \rightarrow \frac{1}{2}CO_2(g)$

49. Following reaction occurring in an automobile $2C_8H_{18}(g) + 25O_2(g) \rightarrow 16CO_2(g) + 18H_2O(g)$. The sign of $\Delta H, \Delta S$ and ΔG would be **[1999]**

(a) +, –, + (b) –, +, –

(c) –, +, + (d) +, +, –

50. The densities of graphite and diamond at 298 K are 2.25 and 3.31 $g\ cm^{-3}$, respectively. If the standard free energy difference (ΔG^o) is equal to 1895 $J\ mol^{-1}$, the pressure at which graphite will be transformed to diamond at 298 K is **[2003]**

(a) $9.92\times10^5\,Pa$ (b) $1.1\times10^9\,Pa$

(c) $9.92\times10^7\,Pa$ (d) $9.92\times10^6\,Pa$

51. Match **List I** (Equations) with **List II** (Type of process) and select the correct option **[2010]**

List I Equations	List II Type of processes
1. $K_p > Q$	(i) Non-spontaneous
2. $\Delta G^o < RT\ \ln Q$	(ii) Equilibrium
3. $K_p = Q$	(iii) Spontaneous and endothermic
4. $T > \frac{\Delta H}{\Delta S}$	(iv) Spontaneous

(a) 1 (i), 2 (ii), 3 (iii), 4 (iv) (b) 1 (iii), 2 (iv), 3 (ii), 4 (i)

(c) 1 (iv), 2 (i), 3 (ii), 4 (iii) (d) 1 (ii), 2 (i), 3 (iv), 4 (iii)

52. For a given reaction $\Delta H = 35.5\,kJ\,mol^{-1}$ and $\Delta S = 83.6\,JK^{-1}mol^{-1}$. The reaction is spontaneous at : (Assume that ΔH and ΔS do not vary with temperature) **[2017]**

(a) $T < 425\,K$ (b) $T > 425\,K$

(c) All temperatures (d) $T > 298\,K$

9. AIIMS

1. The internal energy of a substance **[2001]**

(a) Increases with increase in temperature

(b) Decreases with increase in temperature

(c) Can be calculated by the relation $E = mc^2$

(d) Remains unaffected with change in temperature

2. In thermodynamics, a process is called reversible when **[2001]**

(a) Surroundings and system change into each other

(b) There is no boundary between system and surroundings

(c) The surroundings are always in equilibrium with the system

(d) The system changes into the surroundings spontaneously

3. Internal energy does not include **[1999]**

(a) Nuclear energy

(b) Rotational energy

(c) Vibrational energy

(d) Energy arising by gravitational pull

4. At constant T and P, which one of the following statements is correct for the reaction, $CO(g) + \frac{1}{2}O_2(g) \rightarrow CO_2(g)$ **[1982, 83]**

(a) ΔH is independent of the physical state of the reactants of that compound

(b) $\Delta H > \Delta E$

(c) $\Delta H < \Delta E$

(d) $\Delta H = \Delta E$

5. The enthalpy change (ΔH) for the reaction, $N_2(g) + 3H_2(g) \rightarrow 2NH_3(g)$ is – 92.38 *kJ* at 298 *K*. The internal energy change ΔU at 298 *K* is **[2006]**

(a) – 92.38 *kJ* (b) – 87.42 *kJ*

(c) – 97.34 *kJ* (d) – 89.9 *kJ*

6. For the reaction of one mole of zinc dust with one mole of sulphuric acid in a bomb calorimeter, ΔU and w correspond to **[2005]**

(a) $\Delta U < 0, w = 0$ (b) $\Delta U = 0, w < 0$

(c) $\Delta U > 0, w = 0$ (d) $\Delta U < 0, w > 0$

7. Hess law is applicable for the determination of heat of **[1998]**

(a) Reaction (b) Formation

(c) Transition (d) All of these

8. Enthalpy change for a reaction does not depend upon **[1997]**

(a) The physical states of reactants and products

(b) Use of different reactants for the same product

(c) The nature of intermediate reaction steps

(d) The differences in initial or final temperatures of involved substances

9. Enthalpy of neutralization of acetic acid by *NaOH* is $-50.6\, kJ/mol.$ and the heat of neutralisation of a strong acid with a strong base is – 55.9 *kJ/mol*. What is the value of ΔH for the ionisation of CH_3COOH **[2000]**

(a) + 5.3 *kJ/mol* (b) + 6.2 *kJ/mol*

(c) + 8.2 *kJ/mol* (d) + 9.3 *kJ/mol*

10. Work done during isothermal expansion of one mole of an ideal gas from 10 atm. to 1 atm at 300K is **[2000]**

(a) 4938.8 *J* (b) 4138.8 *J*

(c) 5744.1 *J* (d) 6257.2 *J*

11. One mole of an ideal gas is allowed to expand reversibly and adiabatically from a temperature of 27^oC. If the work done during the process is $3\, kJ$, then final temperature of the gas is $(C_V = 20\, J/K)$ **[2001]**

(a) 100 *K* (b) 150 *K*

(c) 195 *K* (d) 255 *K*

12. For which reaction from the following, ΔS will be maximum **[1982, 83, 94]**

(a) $Ca(s) + \frac{1}{2}O_2(g) \rightarrow CaO(s)$

(b) $CaCO_3(s) \rightarrow CaO(s) + CO_2(g)$

(c) $C(s) + O_2(g) \rightarrow CO_2(g)$

(d) $N_2(g) + O_2(g) \rightarrow 2NO(g)$

13. Which one of the following has ΔS^o greater than zero **[2003]**

(a) $CaO + CO_2(g) \rightleftharpoons CaCO_3(s)$

(b) $NaCl(aq) \rightleftharpoons NaCl(s)$

(c) $NaNO_3(s) \rightleftharpoons Na^+(aq) + NO_3^-(aq)$

(d) $N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$

14. In which of the following neutralisation reactions, the heat of neutralisation will be highest **[1999]**

(a) NH_4OH and CH_3COOH

(b) NH_4OH and HCl

(c) $NaOH$ and CH_3COOH

(d) $NaOH$ and HCl

6. Thermodynamics and Thermochemistry – Answers Keys

1. Basic Concepts

1	c	2	d	3	c	4	b	5	c
6	b	7	b	8	b	9	a	10	a
11	a	12	c	13	c	14	d	15	a
16	c	17	d						

2. First Law of Thermodynamics and Hess Law

1	a	2	d	3	c	4	c	5	b
6	d	7	d	8	b	9	d	10	b
11	d	12	c	13	c	14	b	15	d
16	c	17	b	18	c	19	b	20	c
21	c								

3. IInd & IIIrd Law of Thermodynamics and Entropy

1	d	2	a	3	c	4	d	5	a
6	c	7	a	8	c	9	a	10	b
11	b	12	c	13	c	14	c	15	c
16	c	17	c	18	a	19	c	20	a
21	d	22	a						

4. Heat of Reaction

1	a	2	c	3	c	4	b	5	c
6	a	7	c	8	c	9	b	10	c
11	d	12	b	13	c	14	b	15	a
16	a	17	c	18	b	19	c	20	b
21	c	22	e	23	a	24	c	25	a
26	d	27	a	28	a				

5. Bond Energy

1	c	2	d	3	a	4	a	5	d
6	c								

6. Free Energy and Work Function

1	a	2	b	3	c	4	b	5	c
6	b	7	c	8	b	9	b		

7. IIT-JEE/ AIEEE

1	c	2	c	3	b	4	c	5	a
6	b	7	a	8	c	9	b	10	d
11	c	12	a	13	c	14	d	15	b
16	b	17	d	18	b	19	b	20	a
21	a	22	c	23	d	24	b	25	b
26	b	27	a	28	b	29	c	30	b
31	a	32	a	33	c	34	b	35	a
36	c	37	c	38	d	39	a	40	b
41	a	42	b	43	b	44	c	45	b
46	c	47	a	48	d	49	d	50	b

8. NEET/ AIPMT/ CBSE-PMT

1	b	2	d	3	b	4	d	5	c
6	c	7	c	8	c	9	c	10	a
11	d	12	c	13	d	14	d	15	c
16	c	17	d	18	c	19	c	20	d
21	d	22	c	23	a	24	d	25	c
26	c	27	b	28	a	29	d	30	a
31	b	32	d	33	b	34	c	35	c
36	c	37	c	38	c	39	d	40	a
41	c	42	d	43	d	44	b	45	c
46	b	47	b	48	a	49	b	50	b
51	c	52	b						

9. AIIMS

1	a	**2**	c	**3**	d	**4**	c	**5**	b
6	a	**7**	d	**8**	c	**9**	a	**10**	c
11	b	**12**	b	**13**	c	**14**	d	**15**	b
16	b	**17**	b	**18**	a	**19**	c	**20**	b
21	d	**22**	b	**23**	d	**24**	d	**25**	d
26	d	**27**	d	**28**	c				

10. Assertion & Reason

1	c	**2**	b	**3**	b	**4**	b	**5**	a
6	c	**7**	b	**8**	a	**9**	b	**10**	a
11	a	**12**	b	**13**	a	**14**	c	**15**	a