

**Previous HSE Questions from the chapter "THERMODYNAMICS"**

- State Hess's law of constant heat summation. (2)
- (i) Define extensive and intensive properties. (2)  
(ii) Choose the intensive property from the following:  
(A) Enthalpy (B) Molar volume (C) Heat capacity (D) Internal energy (1)
- The enthalpy and entropy changes for a reaction are  $490 \text{ kJ mol}^{-1}$  and  $198 \text{ J K}^{-1} \text{ mol}^{-1}$ . Calculate the value of Gibb's energy change ( $\Delta_r G$ ) for this reaction at 300 K. Predict whether the reaction is spontaneous at this temperature. (3) [December 2021]
- Write Hess's law of constant heat summation. (2)
- (i) Name the thermodynamic system with exchange of energy and matter with surroundings. (1)  
(ii) State 1<sup>st</sup> law of thermodynamics. (2)
- (i) Define extensive property. (1)  
(ii) Identify extensive property from the following:  
density, mass, pressure, volume (2) [September 2021]
- Calculate the standard enthalpy of reaction:  $\text{CaCO}_3 (\text{s}) \longrightarrow \text{CaO} (\text{s}) + \text{CO}_2 (\text{g})$   
Given  $\Delta_f H^\circ \text{CaCO}_3 (\text{s}) = -1206.92 \text{ kJ/mol}$ ,  $\Delta_f H^\circ \text{CaO} (\text{s}) = -635.09 \text{ kJ/mol}$  and  $\Delta_f H^\circ \text{CO}_2 (\text{g}) = -393.51 \text{ kJ/mol}$  (2)
- (a) State the second law of thermodynamics. (1)  
(b) Define Gibbs energy. (1)  
(c) How the Gibb's energy change and entropy change are related? (1) [December 2020]
- Define extensive and intensive properties. Give examples for each. (2)
- a) Write the mathematical expression of First Law of thermodynamics. (1)  
(b) Define standard enthalpy of formation. (1)  
(c) Write the condition of temperature for a process to be spontaneous whose  $\Delta H$  and  $\Delta S$  values are positive.  
[Hint :  $\Delta G = \Delta H - T\Delta S$ ] (1) [March 2020]
- In a process 701 J of heat is absorbed by a system and 394 J of work is done by the system. The change in internal energy for the process is ..... (1)
- The std. enthalpies of formation of  $\text{CH}_4 (\text{g})$ ,  $\text{CO}_2 (\text{g})$  and  $\text{H}_2\text{O} (\text{l})$  at 298K are  $-74.81 \text{ kJ mol}^{-1}$ ,  $-393.5 \text{ kJ mol}^{-1}$  and  $-285.8 \text{ kJ mol}^{-1}$  respectively. Calculate the std. enthalpy of the reaction:  
 $\text{CH}_4 (\text{g}) + 2 \text{O}_2 (\text{g}) \longrightarrow \text{CO}_2 (\text{g}) + 2\text{H}_2\text{O} (\text{g})$  (2)
- (a) What is a spontaneous process? (1)  
(b) For the reaction,  $4\text{Fe} (\text{s}) + 3\text{O}_2 (\text{g}) \longrightarrow 2 \text{Fe}_2\text{O}_3 (\text{s})$ , the entropy change is  $-549.4 \text{ J K}^{-1} \text{ mol}^{-1}$  at 298 K. In spite of the negative entropy change, why is the reaction spontaneous? Given  $\Delta H^\circ = -1648 \text{ kJ mol}^{-1}$ . (3) [July 2019]
- According to the first law of thermodynamics, for an isolated system,  $\Delta U = \dots\dots\dots$  (1)
- What is meant by spontaneous processes? Give the criterion of spontaneity in terms of  $\Delta G$  for a process taking place at constant temperature and pressure. (2)
- (a) State Hess' law of constant heat summation. (1)  
(b) Calculate the standard enthalpy of formation from the following:  
 $\text{CH}_3\text{OH} (\text{l}) + 3/2 \text{O}_2 (\text{g}) \longrightarrow \text{CO}_2 (\text{g}) + 2 \text{H}_2\text{O} (\text{l}); \Delta_r H^\circ = -726 \text{ kJ mol}^{-1}$   
 $\text{C} (\text{graphite}) + \text{O}_2 (\text{g}) \longrightarrow \text{CO}_2 (\text{g}); \Delta_r H^\circ = -393 \text{ kJ mol}^{-1}$   
 $\text{H}_2 (\text{g}) + 1/2 \text{O}_2 (\text{g}) \longrightarrow \text{H}_2\text{O} (\text{l}); \Delta_r H^\circ = -286 \text{ kJ mol}^{-1}$  (3) [March 2019]
- Differentiate state functions from path functions and give one example for each. (2)

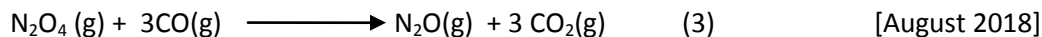
18. First law of thermodynamics can be stated as  $\Delta U = q + w$ . How can this equation be expressed for :

- An isothermal reversible change?
- A process carried out at constant volume? (2)

19. Enthalpies of formation of some compounds are given below :

Compound	CO	CO <sub>2</sub>	N <sub>2</sub> O	N <sub>2</sub> O <sub>4</sub>
Enthalpy of formation (kJ/mol)	-110.0	-393.0	81.0	9.7

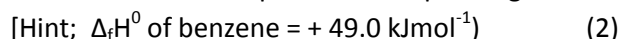
Using these data, calculate the enthalpy of reaction for



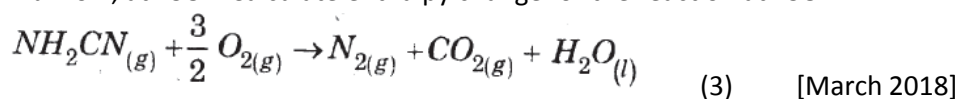
20. What is meant by entropy of a system? What happens to the entropy during the following changes?

- A gas condenses into liquid.
- $\text{CaCO}_3(\text{s}) \longrightarrow \text{CaO}(\text{s}) + \text{CO}_2(\text{g})$  (2)

21. Write the thermochemical equation corresponding to the standard enthalpy of formation of benzene.

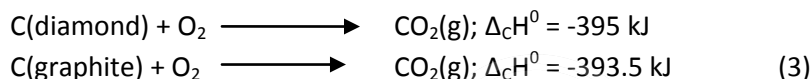


22. The reaction of cyanamide (NH<sub>2</sub>CN) with dioxygen was carried out in a bomb calorimeter and  $\Delta U$  was found to be -7 42.7 kJ mol<sup>-1</sup>, at 298K. Calculate enthalpy change for the reaction at 298 K.



23. a) i) State Hess's law.

ii) Calculate  $\Delta_f H^\circ$  when diamond is formed from graphite.



b) An extensive property is.....

- density
- pressure
- temperature
- mass (1) [July 2017]

24. a) Some macroscopic properties are given below. Help Reena to classify them into two groups under suitable titles.

[Heat capacity, Entropy, Refractive index, Surface tension] (2)

b) For the reaction  $2\text{A}(\text{g}) + \text{B}(\text{g}) \longrightarrow 2\text{D}(\text{g})$ ,  $\Delta U^\circ = -10.5 \text{ kJ/mol}$ ,  $\Delta S^\circ = -44.1 \text{ J/K/mol}$  at 298K. Calculate  $\Delta G^\circ$  for the reaction. (2) [March 2017]

25. a) Which of the following is a process taking place with increase in entropy?

- Freezing of water
- Condensation of steam
- Cooling of a liquid
- Dissolution of a solute (1)

b) State and illustrate Hess's law. (3) [September 2016]

26. The enthalpy change in a process is the same, whether the process is carried out in a single step or in several steps.

a) Identify the law stated here. (1)

b) Calculate the enthalpy of formation of CH<sub>4</sub> from the following data:

- $\text{C}(\text{s}) + \text{O}_2(\text{g}) \rightarrow \text{CO}_2(\text{g}); \Delta H = -393.7 \text{ kJ/mol}$
- $\text{H}_2(\text{g}) + \frac{1}{2}\text{O}_2(\text{g}) \rightarrow \text{H}_2\text{O}(\text{l}); \Delta H = -285.8 \text{ kJ/mol}$
- $\text{CH}_4(\text{g}) + 2\text{O}_2(\text{g}) \rightarrow \text{CO}_2(\text{g}) + 2\text{H}_2\text{O}(\text{l}); \Delta H = -890.4 \text{ kJ/mol}$  (3) [March 2016]

27. Expansion of a gas in vacuum is called free expansion.

a) Which one of the following represents free expansion of an ideal gas under adiabatic conditions?

- $q = 0, \Delta T \neq 0, w = 0$
- $q \neq 0, \Delta T = 0, w = 0$
- $q = 0, \Delta T = 0, w = 0$
- $q = 0, \Delta T < 0, w \neq 0$  (1)

b) The enthalpy change for the reaction  $\text{N}_2(\text{g}) + 3\text{H}_2(\text{g}) \rightarrow 2\text{NH}_3(\text{g})$  is -91.8 kJ at 298 K. Calculate the value of internal energy change. ( $R = 8.314 \text{ JK}^{-1} \text{ mol}^{-1}$ ) (3) [Oct. 2015]

28. a) Classify the following into intensive and extensive properties.

- Internal energy
- Density
- Heat capacity
- Temperature (2)

b) Calculate the standard free energy ( $\Delta G^0$ ) for the conversion of oxygen to ozone  $3/2 \text{ O}_2(\text{g}) \rightarrow \text{O}_3(\text{g})$  at 298K, if the equilibrium constant for the conversion is  $2.47 \times 10^{-29}$ . (Given  $R = 8.314 \text{ JK}^{-1}\text{mol}^{-1}$ ). (2) [March 2015]

29. a)  $\Delta G$  gives a criterion for spontaneity of reactions at a constant pressure and temperature. How is  $\Delta G$  helpful in predicting the spontaneity of the reaction? (2)  
 b) State and explain Hess's law of constant heat summation. (2) [August 2014]
30. a) For the oxidation of iron  $4 \text{ Fe}_{(\text{s})} + 3 \text{ O}_{2(\text{g})} \rightarrow 2\text{Fe}_2\text{O}_{3(\text{s})}$ , entropy change  $\Delta S$  is  $-549.4 \text{ J/K/mol}$  at 298K. In spite of the negative entropy change of this reaction, why is the reaction spontaneous? ( $\Delta_r H^0$  for the reaction is  $-1648 \times 10^3 \text{ Jmol}^{-1}$ ). (2)  
 b) Write the differences between extensive and intensive properties. Give one example of each. (2) [March 2014]
31. a) The enthalpy of combustion of  $\text{CH}_{4(\text{g})}$ ,  $\text{C}(\text{graphite})$  and  $\text{H}_{2(\text{g})}$  at 298K are  $-890.3 \text{ kJ mol}^{-1}$ ,  $-393.5 \text{ kJ mol}^{-1}$  and  $-285.8 \text{ kJ mol}^{-1}$  respectively. Calculate the enthalpy of formation of  $\text{CH}_{4(\text{g})}$ . (2)  
 b) Match the following:

1. $W = -\Delta U$	a) Enthalpy change
2. $\Delta U = 0$	b) Universal gas constant
3. $C_p - C_v$	c) Adiabatic process
4. $q_p$	d) Isothermal process
	e) Cyclic process

(2) [September 2013]

32. Most of the naturally occurring processes are spontaneous.  
 a) Give the criteria for spontaneity of a process in terms of free energy change ( $\Delta G$ ). (1)  
 b) Exothermic reactions associated with a decrease in entropy are spontaneous at lower temperatures. Justify on the basis of Gibbs equation. (1)  
 c) Find the temperature above which the reaction  $\text{MgO}_{(\text{s})} + \text{C}_{(\text{s})} \rightarrow \text{Mg}_{(\text{s})} + \text{CO}_{(\text{g})}$  becomes spontaneous. (Given  $\Delta_r H^0 = 490 \text{ kJ mol}^{-1}$  and  $\Delta_r S^0 = 198 \text{ JKmol}^{-1}$ ). (2) [March 2013]
33. a) Construct an enthalpy diagram for the determination of lattice enthalpy of sodium chloride. (2)  
 b) Enthalpy and entropy changes of a reaction are  $40.63 \text{ kJ/mol}$  and  $108.8 \text{ J/K/mol}$ . Predict the feasibility of the reaction at  $27^\circ\text{C}$ . (2) [September 2012]
34. a) Explain the Hess's law of constant heat summation, with an example. (2)  
 b) Draw the enthalpy diagram for exothermic and endothermic reactions. (2) [September 2012]
35. Thermodynamics deals with energy changes of macroscopic systems.  
 a) Consider a chemical reaction taking place in a closed insulated vessel. To which type of thermodynamic system does it belong? (1)  
 b) State the first law of thermodynamics. (1)  
 c) 3 mol of an ideal gas at 1.5 atm and  $25^\circ\text{C}$  expands isothermally in a reversible manner to twice its original volume against an external pressure of 1 atm. Calculate the work done. ( $R = 8.314 \text{ JK}^{-1}\text{mol}^{-1}$ ) (2) [March 2012]
36. A spontaneous process is an irreversible process and may only be reversed by some external agency.  
 a) Decrease in entropy is the only criterion for spontaneity. Do you agree? Why? (2)  
 b) Calculate the work done for the reversible isothermal expansion of 1 mole of an ideal gas at  $27^\circ\text{C}$ , from a volume of  $10 \text{ dm}^3$  to a volume of  $20 \text{ dm}^3$ . (2) [October 2011]
37. The spontaneity of a process is expressed in terms of a change in Gibbs energy.  
 a) What is mean by change in Gibbs energy of a system? (1)  
 b) How is it related to the enthalpy and entropy of a system? (1)

- c) How is it useful in predicting the feasibility of a process? (2) [March 2011]
38. Lattice enthalpy of an ionic salt is a factor that determines its stability.
- a) Define the lattice enthalpy. (1)
- b) Draw the Born-Haber cycle for the calculation of lattice enthalpy of the ionic crystal NaCl. (3) [September 2010]
39. A system in thermodynamics refers to that part of the universe in which observations are made.
- a) What do you mean by an isolated system? Give an example. (1)
- b) Distinguish between intensive and extensive properties. Give two examples for each. (3) [March 2010]
40. a) State Hess's law of constant heat summation. (2)
- b) The equilibrium constant for a reaction is 5. What will be the value of  $\Delta G^0$ ? Given that  $R = 8.314 \text{ J/K/mol}$ ,  $T = 300\text{K}$ . (2) [March 2009]
41. Some properties are "state functions".
- a)  $q$  and  $w$  are not state functions, but  $(q+w)$  is a state function. Why? (1)
- b) What do you mean by saying that pressure is an intensive property? (1)
- c) What is the difference in internal energy of a system, if 100 kJ of energy is radiated out without doing any work? (1) [February 2008]

+++++

