CHEMISTRY (CODE - 043)

CHAPTER TEST - QUESTION PAPER

Class XI (2026-27) | Chapter 5: Thermodynamics

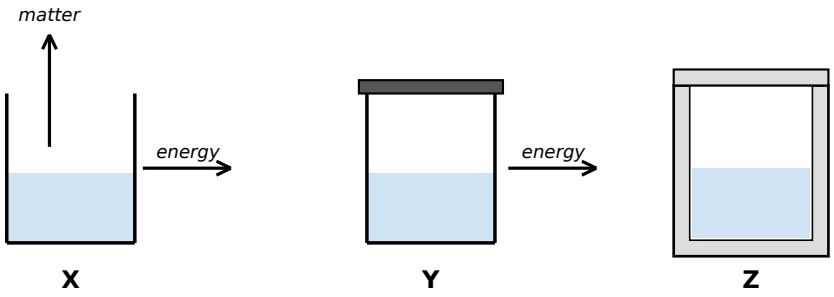
Time: 1 hour 30 minutes | Max. Marks: 35

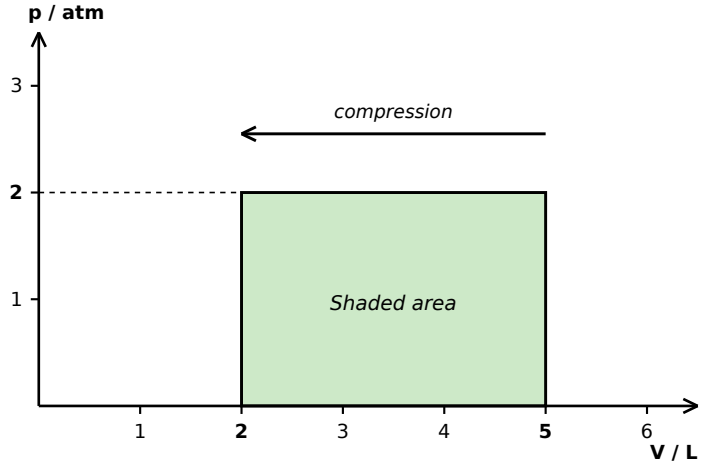
GENERAL INSTRUCTIONS:

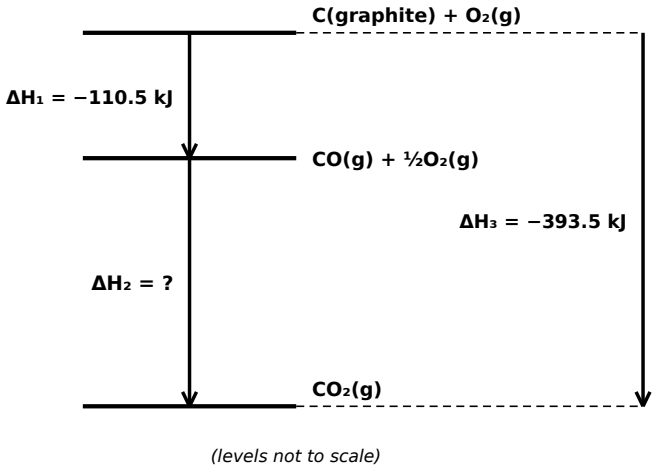
1. Read the following instructions carefully.
2. There are 20 questions in this question paper with internal choice.
3. SECTION A consists of 12 questions carrying 1 mark each (Q. 1 to 9 are multiple-choice questions and Q. 10 to 12 are Assertion–Reason questions).
4. SECTION B consists of 4 very short answer questions carrying 2 marks each.
5. SECTION C consists of 2 short answer questions carrying 3 marks each.
6. SECTION D consists of 1 case-based question carrying 4 marks.
7. SECTION E consists of 1 long answer question carrying 5 marks.
8. All questions are compulsory. Internal choice is provided in Q. 16 (Section B) and Q. 20 (Section E).
9. Use of log tables and calculators is not allowed.
10. Constants: R = 8.314 J K^{-1} mol^{-1}.

SECTION A

Questions 1 to 9 are multiple-choice questions. Only one of the choices is correct. Questions 10 to 12 are Assertion–Reason questions.

1	Which of the following pairs consists of state functions only? A. q and w B. q and H C. U and H D. w and U	1
2	The figure shows three vessels X, Y and Z. Arrows show the exchange of matter and energy between the contents (shaded) and the surroundings. Vessel Z has thick insulated walls and a lid.  The systems X, Y and Z are respectively: A. open, closed, isolated B. closed, open, isolated C. isolated, closed, open D. open, isolated, closed	1
3	For the reaction $2SO_2(g) + O_2(g) \rightarrow 2SO_3(g)$ at 300 K, the value of $(\Delta H - \Delta U)$ is closest to: A. +2.49 kJ B. −2.49 kJ C. zero D. −4.99 kJ	1

4	The figure shows the p–V diagram for the compression of an ideal gas in a single step against a constant external pressure. The shaded area represents the work.  The work done on the gas is: A. −6 L atm B. +10 L atm C. +4 L atm D. +6 L atm	1
5	Which of the following equations represents the **standard enthalpy of formation** of HBr(g)? A. $H_2(g) + Br_2(l) \rightarrow 2HBr(g)$ B. $\frac{1}{2}H_2(g) + \frac{1}{2}Br_2(g) \rightarrow HBr(g)$ C. $\frac{1}{2}H_2(g) + \frac{1}{2}Br_2(l) \rightarrow HBr(g)$ D. $H(g) + Br(g) \rightarrow HBr(g)$	1
6	The signs of ΔH and ΔS for four reactions P, Q, R and S are given below. **Reaction** / **ΔH** / **ΔS** P / − / + Q / − / − R / + / + S / + / − Which reaction is non-spontaneous at all temperatures and which is spontaneous at all temperatures, respectively? A. P; S B. S; P C. Q; R D. R; Q	1

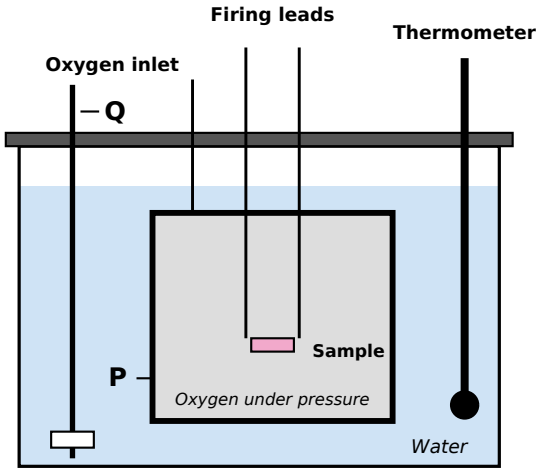
7	The figure shows the enthalpy levels for the oxidation of carbon (graphite) to CO_2 by two routes.  *(levels not to scale)* The value of ΔH_2 is: A. -283.0 kJ mol^{-1} B. -504.0 kJ mol^{-1} C. $+283.0$ kJ mol^{-1} D. -110.5 kJ mol^{-1}	1
8	For a reaction, $\Delta H = +40$ kJ mol^{-1} and $\Delta S = +0.10$ kJ K^{-1} mol^{-1}. Assuming ΔH and ΔS do not change with temperature, the reaction becomes spontaneous above: A. 40 K B. 400 K C. 4000 K D. 298 K	1
9	A system absorbs 500 J of heat and does 200 J of work on the surroundings. The change in internal energy of the system is: A. +700 J B. −300 J C. −700 J D. +300 J	1
10	Questions 10 to 12 are Assertion (A) and Reason (R) type questions. Select the correct option. **Assertion (A):** The enthalpy change of a reaction is the same whether it takes place in one step or in several steps. **Reason (R):** Enthalpy is a state function. A. Both A and R are true, and R is the correct explanation of A. B. Both A and R are true, and R is not the correct explanation of A. C. A is true but R is false. D. A is false but R is true.	1
11	**Assertion (A):** The molar enthalpy of vaporisation of water is positive. **Reason (R):** The entropy of water increases when it changes from liquid to vapour. A. Both A and R are true, and R is the correct explanation of A. B. Both A and R are true, and R is not the correct explanation of A. C. A is true but R is false. D. A is false but R is true.	1

12	**Assertion (A):** In the free expansion of an ideal gas into vacuum at constant temperature, w = 0 and ΔU = 0. **Reason (R):** In free expansion the external pressure is infinite. A. Both A and R are true, and R is the correct explanation of A. B. Both A and R are true, and R is not the correct explanation of A. C. A is true but R is false. D. A is false but R is true.	1

SECTION B

Questions 13 to 16 are very short answer questions carrying 2 marks each.

13 The figure shows a bomb calorimeter used to measure the heat of combustion. — 2



(i) Name the parts P and Q. Does this apparatus measure ΔU or ΔH? Give a reason. [1]
(ii) 1.2 g of carbon (graphite) is burnt completely to CO_2 in this calorimeter. The temperature rises by 2.0 K and the heat capacity of the calorimeter is 20.0 kJ K^{-1}. Calculate ΔH for the combustion of 1 mol of carbon. (Atomic mass of C = 12) [1]

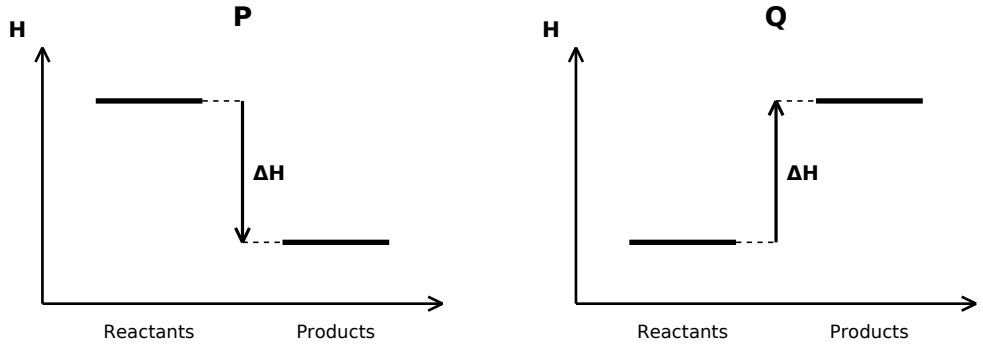
14 Standard enthalpies of vaporisation of some liquids at their boiling points are given below. — 2

Substance	T_b / K	$\Delta_{vap}H$ / kJ mol^{-1}
H_2O	373.15	40.79
C_6H_6	353.25	30.8
CH_3COCH_3	329.4	29.1
CCl_4	349.69	30.0

(i) Calculate the heat required to vaporise 78 g of benzene at its boiling point. (Molar mass of C_6H_6 = 78 g mol^{-1}) [1]
(ii) Why is the enthalpy of vaporisation of water much greater than that of acetone? [1]

15 Predict whether the entropy of the system **increases or decreases** in each of the following. Give a reason in one line for each. — 2

(a) $H_2O(l) \rightarrow H_2O(g)$
(b) $CaCO_3(s) \rightarrow CaO(s) + CO_2(g)$
(c) $N_2(g) + 3H_2(g) \rightarrow 2NH_3(g)$
(d) Water freezing to ice at 273 K [½ + ½ + ½ + ½]

16	The figure shows the enthalpy diagrams P and Q for two reactions.  (i) Identify each as exothermic or endothermic and write the sign of ΔH. [1] (ii) Can the reaction in Q be spontaneous? Justify your answer using the Gibbs equation. [1] **OR** One mole of water is vaporised at 373 K and 1 bar. $\Delta_{vap}H$ = 40.7 kJ mol^{-1}. Calculate the change in internal energy (assume steam behaves as an ideal gas). R = 8.314 J K^{-1} mol^{-1}.	2

SECTION C

Questions 17 and 18 are short answer questions carrying 3 marks each.

17	Mean bond enthalpies (kJ mol^{-1}) at 298 K are given below. All species are in the gaseous state. **Bond** | **C–H** | **O=O** | **C=O** | **O–H** Mean bond enthalpy | 414 | 498 | 741 | 464 For the reaction $CH_4(g) + 2O_2(g) \rightarrow CO_2(g) + 2H_2O(g)$: (i) List the bonds broken and the bonds formed. [1] (ii) Calculate $\Delta_r H$ using bond enthalpies. [1] (iii) Why is the value obtained only approximate? [1]	3
18	The following enthalpies of combustion (kJ mol^{-1}) are given at 298 K: (1) $C_2H_4(g) + 3O_2(g) \rightarrow 2CO_2(g) + 2H_2O(l)$; $\Delta H = -1411$ (2) $C_2H_6(g) + 7/2\ O_2(g) \rightarrow 2CO_2(g) + 3H_2O(l)$; $\Delta H = -1560$ (3) $H_2(g) + ½O_2(g) \rightarrow H_2O(l)$; $\Delta H = -286$ (i) State Hess's law of constant heat summation. [1] (ii) Show how equations (1), (2) and (3) are combined to get the equation for the hydrogenation of ethene, $C_2H_4(g) + H_2(g) \rightarrow C_2H_6(g)$. [1] (iii) Calculate $\Delta_r H$ for the hydrogenation and state whether it is exothermic or endothermic. [1]	3

SECTION D

Question 19 is a case-based question carrying 4 marks.

19	**Burning of limestone** Lime (CaO) is made industrially by heating limestone in a kiln: $CaCO_3(s) \rightarrow CaO(s) + CO_2(g)$. The standard enthalpies of formation at 298 K and the entropy change of the reaction are given.	4

Substance	$CaCO_3(s)$	$CaO(s)$	$CO_2(g)$
$\Delta_f H°$ / kJ mol^{-1}	−1206.9	−635.1	−393.5

Entropy change of the reaction, $\Delta_r S° = +160$ J K^{-1} mol^{-1}.

(i) Define the standard enthalpy of formation. [1]

(ii) Calculate $\Delta_r H°$ for the decomposition of $CaCO_3$. [1]

(iii) Calculate $\Delta_r G°$ at 298 K and say whether the decomposition is spontaneous at this temperature. [1]

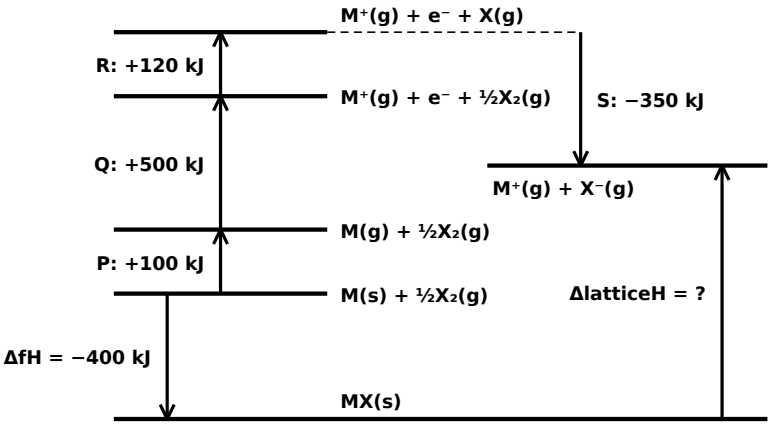
(iv) Above what temperature does the decomposition become spontaneous? (Assume $\Delta_r H°$ and $\Delta_r S°$ are constant.) [1]

SECTION E

Question 20 is a long answer question carrying 5 marks.

20	The figure shows the Born–Haber cycle for an ionic solid MX. X_2 is a diatomic gas.	5

Enthalpy (not to scale)



(i) Name the enthalpy changes P, Q, R and S. [2]

(ii) Calculate the lattice enthalpy of MX(s). [1½]

(iii) The sum of the hydration enthalpies of M^+ and X^- is −760 kJ mol^{-1}. Calculate the enthalpy of solution of MX. [1]

(iv) Will the solubility of MX in water increase or decrease on heating? Give a reason. [½]

OR

For the synthesis of ammonia, $N_2(g) + 3H_2(g) \rightarrow 2NH_3(g)$, $\Delta_r H = -92$ kJ mol^{-1} and $\Delta_r S = -200$ J K^{-1} mol^{-1} (assume both constant).

(i) Write the Gibbs equation and the condition of spontaneity in terms of ΔG. [1]

(ii) Calculate ΔG at 298 K. Is the reaction spontaneous? [1]

(iii) Above which temperature does the reaction become non-spontaneous? [1]

(iv) Calculate ΔG at 600 K and state your conclusion. [1]

(v) Write the relation between $\Delta_r G°$ and the equilibrium constant K. What does a large negative $\Delta_r G°$ indicate about K? [1]

***** END OF QUESTION PAPER *****