

IB Chemistry SL Paper 2 Mock Paper (fourth set, 10 questions, 50 marks, 75 minutes, calculator allowed)

IB DP 第一年 (Grade 11) Chemistry | 時限 : 75 分鐘 | 總分 : 50 分 | 共 10 題

Section A (Questions 1 to 5, 25 marks)

Answer ALL questions. A calculator may be used. Show your working in calculations, give numerical answers to three significant figures unless told otherwise, and state units in every final answer. All data are examples and this is not a past paper of any examination board.

1. (a) Write the equation for the reaction between magnesium and dilute hydrochloric acid. (b) Calculate the number of moles in 2.40 g of magnesium (Ar: Mg = 24.3). (c) Calculate the volume of hydrogen collected at room temperature and pressure (molar volume $24.0 \text{ dm}^3 \text{ mol}^{-1}$). (d) State and explain whether the measured volume would be larger or smaller if the gas were not cooled to room temperature.

答案 : (a) $\text{Mg(s)} + 2\text{HCl(aq)} \rightarrow \text{MgCl}_2 \text{ (aq)} + \text{H}_2 \text{ (g)}$. (b) $n(\text{Mg}) = 2.40 / 24.3 = 0.0988 \text{ mol}$. (c) mole ratio $\text{H}_2 : \text{Mg} = 1 : 1$, so $n(\text{H}_2) = 0.0988 \text{ mol}$ and $V = 0.0988 \times 24.0 = 2.37 \text{ dm}^3$. (d) Larger, because a hot gas expands and the same number of moles occupies a greater volume. Marking notes: 1 mark for (a); 1 for (b); 2 for (c) (mole ratio and volume); 1 for (d).

2. 0.500 g of ethanol (Mr = 46.0) burns completely in oxygen and raises the temperature of 150 g of water from 21.0°C to 33.0°C (specific heat capacity of water $4.18 \text{ J g}^{-1} \text{ K}^{-1}$). (a) Calculate the heat absorbed by the water in J. (b) Calculate the number of moles of ethanol burnt. (c) Calculate the enthalpy change of combustion of ethanol in kJ mol^{-1} . (d) Explain why the experimental value differs greatly from the literature value of $-1367 \text{ kJ mol}^{-1}$.

答案 : (a) $q = mc\Delta T = 150 \times 4.18 \times 12.0 = 7524 \text{ J}$. (b) $n(\text{ethanol}) = 0.500 / 46.0 = 0.01087 \text{ mol}$. (c) $\Delta H = -7524 / 0.01087 / 1000 = -692.2 \text{ kJ mol}^{-1}$. (d) Heat is lost to the surroundings, combustion may be incomplete and some water evaporates, so the heat released is underestimated and the magnitude of the experimental value is much smaller. Marking notes: 1 mark for (a); 1 for (b); 2 for (c) (sign and value); 1 for (d).

3. In a 1.00 dm^3 vessel, 0.500 mol of H_2 and 0.500 mol of I_2 react at constant temperature until equilibrium is reached, when the concentration of HI is $0.760 \text{ mol dm}^{-3}$. $\text{H}_2 \text{ (g)} + \text{I}_2 \text{ (g)} \rightleftharpoons 2\text{HI(g)}$ (a) Calculate the number of moles of H_2 used. (b) State the equilibrium concentrations of H_2 and I_2 . (c) Write the Kc expression and calculate Kc. (d) Explain whether Kc changes when the vessel is compressed to half its volume.

答案 : (a) 2 mol of HI come from 1 mol of H_2 , so $\text{H}_2 \text{ used} = 0.760 / 2 = 0.380 \text{ mol}$. (b) $[\text{H}_2] = [\text{I}_2] = 0.500 - 0.380 = 0.120 \text{ mol dm}^{-3}$. (c) $K_c = [\text{HI}]^2 / ([\text{H}_2][\text{I}_2]) = 0.760^2 / 0.120^2 = 40.1$ (no units). (d) It does not change; Kc depends only on temperature, and changing the volume changes the concentrations but not the value of the quotient at constant temperature. Marking notes: 1 mark for (a); 2 for (b); 1 for (c); 1 for (d).

4. A current of 2.50 A is passed through copper(II) sulphate solution for 40.0 minutes using inert electrodes ($F = 96\,500\text{ C mol}^{-1}$, molar volume $24.0\text{ dm}^3\text{ mol}^{-1}$, Ar: Cu = 63.5). (a) Calculate the charge passed in C. (b) Calculate the number of moles of electrons. (c) Calculate the mass of copper deposited at the cathode. (d) Calculate the volume of oxygen formed at the anode.

答案 : (a) $Q = It = 2.50 \times 2400 = 6000\text{ C}$. (b) $n(e^-) = 6000 / 96500 = 0.0622\text{ mol}$. (c) $\text{Cu}^{2+} + 2e^- \rightarrow \text{Cu}$, so $n(\text{Cu}) = 0.0622 / 2$ and $m = 0.0311 \times 63.5 = 1.97\text{ g}$. (d) $2\text{H}_2\text{O} \rightarrow \text{O}_2 + 4\text{H}^+ + 4e^-$, so $n(\text{O}_2) = 0.0622 / 4 = 0.0155\text{ mol}$ and $V = 0.0155 \times 24.0 = 0.373\text{ dm}^3$. Marking notes: 1 mark for (a); 1 for (b); 1 for (c); 2 for (d) (mole ratio and volume).

5. A first order reaction has a rate constant $k = 4.62 \times 10^{-3}\text{ s}^{-1}$ at 298 K. (a) Calculate the half-life. (b) Starting from 0.800 mol dm^{-3} , calculate the concentration remaining after 450 s. (c) Calculate the percentage remaining after 450 s. (d) State how rate depends on concentration for a first order reaction and describe the shape of the concentration against time graph.

答案 : (a) $t_{1/2} = \ln 2 / k = 0.693 / 4.62 \times 10^{-3} = 150.0\text{ s}$. (b) 450 s is 3 half-lives, so the concentration left is $0.800 \times (1/2)^3 = 0.100\text{ mol dm}^{-3}$. (c) Percentage remaining = $(1/2)^3 \times 100 = 12.5\text{ per cent}$. (d) The rate is directly proportional to concentration (rate = $k[A]^1$); the concentration against time graph is a decaying exponential curve, falling faster when the concentration is higher. Marking notes: 1 mark for (a); 2 for (b); 1 for (c); 1 for (d).

Section B (Questions 6 to 10, 25 marks)

Answer ALL questions. A calculator may be used. Show your working in calculations, give numerical answers to three significant figures unless told otherwise, and state units in every final answer. All data are examples and this is not a past paper of any examination board.

6. At 25°C a weak acid HA has $K_a = 1.80 \times 10^{-5}$. (a) Write the K_a expression and calculate $[\text{H}^+]$ in $0.0200\text{ mol dm}^{-3}$ HA, assuming the degree of ionisation is small. (b) Calculate the pH of this solution. (c) Calculate the pH after the solution is diluted ten times. (d) Explain why the pH rises by less than one unit on dilution.

答案 : (a) $K_a = [\text{H}^+][\text{A}^-] / [\text{HA}]$, so $[\text{H}^+] = \sqrt{(K_a \times c)} = \sqrt{(1.80 \times 10^{-5} \times 0.0200)} = 6.00 \times 10^{-4}\text{ mol dm}^{-3}$. (b) $\text{pH} = -\log(6.00 \times 10^{-4}) = 3.22$. (c) After ten-fold dilution $c = 0.00200\text{ mol dm}^{-3}$, $[\text{H}^+] = 1.90 \times 10^{-4}\text{ mol dm}^{-3}$ and $\text{pH} = 3.72$. (d) A weak acid is only partly ionised; on dilution the degree of ionisation increases and replaces some of the lost H^+ , so $[\text{H}^+]$ falls by about a factor of $\sqrt{10}$ and the pH rises by only 0.50 instead of 1.00. Marking notes: 2 marks for (a); 1 for (b); 1 for (c); 1 for (d).

7. A compound contains 40.0 per cent carbon, 6.7 per cent hydrogen and 53.3 per cent oxygen by mass, and has a relative molecular mass of 180 (Ar: C = 12.01, H = 1.008, O = 16.00). (a) Calculate the mole ratio and deduce the empirical formula. (b) Calculate the empirical formula mass. (c) Deduce the molecular formula. (d) The compound reduces ammoniacal silver nitrate; name the compound.

答案 : (a) $n(\text{C}) : n(\text{H}) : n(\text{O}) = 40.0/12.01 : 6.7/1.008 : 53.3/16.00 = 3.331 : 6.647 : 3.331$, which simplifies to 1 : 2.0 : 1.0, so the empirical formula is CH_2O . (b) Empirical formula mass = $12.01 + 2 \times 1.008 + 16.00 = 30.03$. (c) $180 / 30.03 = 5.99$, about 6, so the molecular formula is $\text{C}_6\text{H}_{12}\text{O}_6$. (d) Glucose, a hexose aldo-sugar. Marking notes: 2 marks for (a); 1 for (b); 1 for (c); 1 for (d).

8. 25.0 cm³ of 0.500 mol dm⁻³ hydrochloric acid is mixed with 25.0 cm³ of 0.500 mol dm⁻³ sodium hydroxide in a polystyrene cup and the temperature rises by 3.5 ° C. Assume the mixture has density 1.00 g cm⁻³ and specific heat capacity 4.18 J g⁻¹ K⁻¹, and that heat loss is negligible. (a) Calculate the mass of the mixture. (b) Calculate the heat released. (c) Calculate the number of moles of water formed. (d) Calculate the enthalpy change of neutralisation and compare it with the literature value of -57.3 kJ mol⁻¹.

答案 : (a) Mass = (25.0 + 25.0) x 1.00 = 50.0 g. (b) q = mcΔT = 50.0 x 4.18 x 3.5 = 731.5 J. (c) n(H₂ O) = 0.500 x 25.0 / 1000 = 0.0125 mol, since the acid and alkali are present in equal amounts and react completely. (d) ΔH = -731.5 / 0.0125 / 1000 = -58.5 kJ mol⁻¹, which is close to the literature value of -57.3 kJ mol⁻¹; the difference comes from heat loss, the solution not being pure water and measurement error. Marking notes: 1 mark for (a); 1 for (b); 1 for (c); 2 for (d) (value and comparison).

9. 25.0 cm³ of iron(II) sulphate solution of unknown concentration is titrated in acidic conditions with 0.0200 mol dm⁻³ potassium permanganate solution; 18.5 cm³ is required to reach the end point. (a) Write the half-equation for the reduction of MnO₄⁻ to Mn²⁺. (b) Calculate the number of moles of MnO₄⁻ used. (c) Using electron balance, calculate the number of moles of Fe²⁺. (d) Calculate the concentration of the Fe²⁺ solution.

答案 : (a) MnO₄⁻ + 8H⁺ + 5e⁻ → Mn²⁺ + 4H₂ O. (b) n(MnO₄⁻) = 0.0200 x 0.0185 = 3.70e-04 mol. (c) Each mole of MnO₄⁻ takes 5 moles of electrons and each mole of Fe²⁺ gives 1 mole, so n(Fe²⁺) = 5 x 3.70e-04 = 1.85e-03 mol. (d) [Fe²⁺] = 1.85e-03 / 0.0250 = 0.0740 mol dm⁻³. Marking notes: 1 mark for (a); 1 for (b); 2 for (c) (electron ratio and moles); 1 for (d).

10. 12.0 g of ethanol is heated with 18.0 g of ethanoic acid and a concentrated sulphuric acid catalyst to form ethyl ethanoate (Mr: ethanol 46.0, ethanoic acid 60.05, ethyl ethanoate 88.1). (a) Calculate the moles of each reactant and identify the limiting reagent. (b) Calculate the theoretical yield of ethyl ethanoate in g. (c) The actual yield is 16.5 g; calculate the percentage yield. (d) Suggest two ways of increasing the yield.

答案 : (a) n(ethanol) = 12.0 / 46.0 = 0.2609 mol; n(ethanoic acid) = 18.0 / 60.05 = 0.2998 mol; ethanol is in smaller amount, so it is the limiting reagent. (b) The mole ratio is 1 : 1, so the theoretical amount is 0.2609 mol, giving 0.2609 x 88.1 = 22.98 g. (c) Percentage yield = 16.5 / 22.98 x 100 = 71.8 per cent. (d) Use an excess of the cheaper reactant (ethanol) to push the equilibrium to the right, and remove the ester or the water continuously, for example by distilling off the ester, so that the equilibrium keeps shifting right. Marking notes: 2 marks for (a); 1 for (b); 1 for (c); 1 for (d).