

IB Chemistry SL Paper 2 Mock Paper (third 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.

- At 298 K and 101.3 kPa a vessel contains 2.80 g of nitrogen (N_2 , molar mass 28.0 g mol⁻¹). (a) Calculate the amount, in moles, of nitrogen. (b) Use the ideal gas equation $PV = nRT$ to calculate the volume of this gas under these conditions, in dm³ ($R = 8.314 \text{ J K}^{-1} \text{ mol}^{-1}$). (c) The temperature is raised to 350 K at constant pressure. Calculate the new volume in dm³. (d) At the same temperature and pressure, the 2.80 g of nitrogen is replaced by 2.80 g of helium (He, molar mass 4.00 g mol⁻¹). Calculate how many times larger the new volume is. (e) Explain why a real gas deviates noticeably from the ideal gas equation at very high pressure.
- The Haber process for ammonia is $\text{N}_2(\text{g}) + 3\text{H}_2(\text{g}) \rightarrow 2\text{NH}_3(\text{g})$. 0.250 mol of nitrogen and 0.600 mol of hydrogen are placed in a reactor (molar masses: N_2 28.0, H_2 2.00, NH_3 17.0 g mol⁻¹). (a) Calculate the amount of hydrogen, in moles, needed to react completely with the nitrogen. (b) Identify the limiting reactant and justify your answer. (c) Calculate the theoretical amount of ammonia formed, in moles. (d) Calculate the theoretical mass of ammonia formed, in grams. (e) The actual yield is 80%. Calculate the mass of ammonia actually formed in grams and state how much nitrogen remains in the reactor.
- First ionisation energies in kJ mol⁻¹: Na 496, Mg 738, Al 577, Si 786, P 1012, Cl 1251, Ne 2081. (a) Write the electron configurations of Na, Mg and Al in the form 1s² 2s² 2p⁶ ... (b) Explain why the first ionisation energy of Al is lower than that of Mg. (c) Explain why the first ionisation energy of P is higher than that of Si. (d) Describe the trend in atomic radius from Na to Cl and explain its cause. (e) Explain why Ne has the highest first ionisation energy in this period.
- Consider the molecules CH_4 , NH_3 , H_2O , BF_3 and CO_2 . (a) State the number of electron domains, the shape and the H-C-H bond angle of CH_4 . (b) State the shape and the H-N-H bond angle of NH_3 and explain why it is smaller than in CH_4 . (c) State the shape and the H-O-H bond angle of H_2O and explain the difference from NH_3 . (d) Explain why BF_3 is trigonal planar rather than trigonal pyramidal. (e) Explain why CO_2 is linear and has no net dipole moment.

5. A current of 0.500 A is passed through copper(II) sulfate solution for 30.0 minutes, with inert electrodes. Copper (molar mass 63.55 g mol⁻¹) is deposited at the cathode. Faraday constant $F = 96500 \text{ C mol}^{-1}$, molar gas volume at room temperature 24.0 dm³. (a) Calculate the quantity of charge passed, in coulombs. (b) Calculate the amount of electrons passed, in moles. (c) Write the half-equation at the cathode and calculate the mass of copper deposited in grams. (d) Write the half-equation at the anode and calculate the volume of oxygen formed at room temperature, in cm³. (e) If the current efficiency is only 90%, state how the mass of copper deposited changes.

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. The initial rates for the reaction $A + B \rightarrow C$ at one temperature are: Experiment 1: $[A] = 0.10 \text{ mol dm}^{-3}$, $[B] = 0.10 \text{ mol dm}^{-3}$, rate = $2.0 \times 10^{-3} \text{ mol dm}^{-3} \text{ s}^{-1}$ Experiment 2: $[A] = 0.20 \text{ mol dm}^{-3}$, $[B] = 0.10 \text{ mol dm}^{-3}$, rate = $4.0 \times 10^{-3} \text{ mol dm}^{-3} \text{ s}^{-1}$ Experiment 3: $[A] = 0.20 \text{ mol dm}^{-3}$, $[B] = 0.20 \text{ mol dm}^{-3}$, rate = $1.6 \times 10^{-2} \text{ mol dm}^{-3} \text{ s}^{-1}$ (a) Deduce the order of reaction with respect to A. (b) Deduce the order of reaction with respect to B. (c) Write the rate equation and state the overall order. (d) Calculate the value and unit of the rate constant k . (e)

Calculate the initial rate when $[A] = 0.15 \text{ mol dm}^{-3}$ and $[B] = 0.25 \text{ mol dm}^{-3}$.

7. Industrial ammonia synthesis: $\text{N}_2(\text{g}) + 3\text{H}_2(\text{g}) \rightleftharpoons 2\text{NH}_3(\text{g})$, enthalpy change of reaction -92 kJ mol^{-1} . (a) Explain the effect of increasing the total pressure on the equilibrium yield of ammonia. (b) Explain the effects of increasing the temperature on the equilibrium yield and on the rate. (c) Explain the effect of continuously condensing and removing ammonia. (d) Explain the effect of adding an iron catalyst on the position of equilibrium and on the time taken to reach equilibrium. (e) Explain why industry uses about 450 degrees C rather than a much lower temperature.

8. 0.100 mol of ethanoic acid (CH_3COOH) is heated under reflux with excess ethanol and concentrated sulfuric acid to form ethyl ethanoate. (a) Write the equilibrium equation for this esterification and name the catalyst required. (b) Give the systematic name and molecular formula of the organic product. (c) The molar mass of the ester is 88.0 g mol⁻¹. Calculate the mass of ester formed in grams if the yield is 80 per cent. (d) Name two other esters that are isomers with the molecular formula $\text{C}_4\text{H}_8\text{O}_2$. (e) Explain why the reaction is heated under reflux and why the ester is separated by fractional distillation afterwards.

9. Standard enthalpies of formation in kJ mol⁻¹: $\text{CH}_4(\text{g}) -75$, $\text{CO}_2(\text{g}) -394$, $\text{H}_2\text{O}(\text{l}) -286$. (a) Define the standard enthalpy of formation, including the standard conditions. (b) Write the balanced equation for the complete combustion of methane, showing all state symbols. (c) Write the expression, or an energy cycle, that gives the enthalpy of combustion from standard enthalpies of formation. (d) Calculate the standard enthalpy of combustion of methane in kJ mol⁻¹. (e) Explain why a calculation using average bond enthalpies gives a different value.

10. Compound X contains only carbon, hydrogen and oxygen. Its mass spectrum shows a molecular ion peak at m/z 60 and prominent fragment peaks at m/z 43 and m/z 45. The infrared spectrum has a broad, strong absorption between 2500 and 3300 cm^{-1} and another strong absorption near 1700 cm^{-1} . (a) Use the mass spectrum to state the relative molecular mass of X. (b) Identify the functional groups responsible for the two infrared absorptions. (c) Given a molar mass of 60.0 g mol^{-1} , deduce the molecular formula of X (relative atomic masses: C 12.0, H 1.0, O 16.0). (d) Using all the evidence, name compound X. (e) Explain the origin of the fragment peak at m/z 45.