S4 Chemistry Practice Paper: Acid-Base and Redox Titration, Electrolysis, Rates of Reaction and Enthalpy Change

S4 Chemistry | Time allowed: 90 minutes | Total: 100 marks | 24 questions

A. Acid-Base Neutralisation and pH (17 marks)

All volumes are in cm³; give answers to 3 significant figures.

1. 25.0 cm³ of 0.100 M NaOH is neutralised by 0.125 M HCl. Find the volume of HCl required. (4 marks)

2. Find the pH of 0.010 M HCl at 25 °C, assuming complete dissociation. (4 marks)

3. Find the pH of 0.0020 M $Ba(OH)_2$ solution, assuming complete dissociation. (5 marks)

4. 20.0 cm³ of 0.100 M H_2SO_4 is mixed with 30.0 cm³ of 0.150 M NaOH. Find the pH of the mixture. (4 marks)

B. Redox Titration (17 marks)

$MnO_4^- + 8H^+ + 5e^- \rightarrow Mn^{2+} + 4H_2O$; $Cr_2O_7^{2-} + 14H^+ + 6e^- \rightarrow 2Cr^{3+} + 7H_2O$.

5. 25.0 cm³ of a solution containing Fe^{2+} needs 18.0 cm³ of 0.0200 M $KMnO_4$ to reach the end point. Find the concentration of Fe^{2+}. (5 marks)

6. Find the oxidation number of manganese in MnO_4^- and of chromium in $Cr_2O_7^{2-}$. (4 marks)

7. What volume of 0.0200 M $K_2Cr_2O_7$ is needed to oxidise 25.0 cm³ of 0.100 M $FeSO_4$ completely? (4 marks)

8. How many moles of electrons are transferred when 1.00 g of copper is oxidised completely to Cu^{2+}? (Relative atomic mass of Cu = 63.5) (4 marks)

C. Electrolysis and Electroplating (17 marks)

Take the Faraday constant as 96 500 C mol⁻¹; relative atomic masses: Cu 63.5, Ag 107.9, Ni 58.7.

9. A current of 2.50 A passes through copper(II) sulphate solution for 30.0 minutes. Find the mass of copper deposited at the cathode. (5 marks)

10. A current of 0.500 A passes through silver nitrate solution for 60.0 minutes. Find the mass of silver deposited at the cathode. (4 marks)

11. A current of 1.00 A electrolyses water for 2.00 hours. Find the volume of hydrogen collected at the cathode at room temperature (molar volume 24.0 dm³ mol⁻¹). (4 marks)

12. Nickel is electroplated with a current of 0.800 A for 45.0 minutes at 90% current efficiency. Find the mass of nickel deposited. (4 marks)

D. Rates of Reaction (17 marks)

Rates are in mol dm^{-3} s^{-1} or cm^3 s^{-1}; give answers to 3 significant figures.

13. For the reaction 2A + B → C, the concentration of A falls from 0.800 M to 0.200 M in 60 s. Find the average rate of disappearance of A and the average rate of formation of C. (5 marks)

14. A first order reaction has a half-life of 20 minutes and an initial concentration of 0.400 M. Find the concentration after 60 minutes. (4 marks)

15. The rate of a reaction doubles for every 10 °C rise in temperature. By what factor does the rate increase when the temperature rises from 20 °C to 60 °C? (4 marks)

16. Zinc reacts with dilute hydrochloric acid: 24.0 cm³ of hydrogen is collected in the first 30 s and the theoretical total is 96.0 cm³. Find the average rate of production and the time needed to complete the reaction. (4 marks)

E. Enthalpy Change and Energy (16 marks)

Take the specific heat capacity of water as 4.18 J g^{-1} K^{-1} and the density of the solutions as 1.00 g cm^{-3}.

17. 50.0 cm³ of 1.00 M HCl is mixed with 50.0 cm³ of 1.00 M NaOH and the temperature rises by 6.8 °C. Find the enthalpy change of neutralisation in kJ mol^{-1}. (5 marks)

18. 0.320 g of methanol (Mr 32.0) burns completely and raises the temperature of 150 g of water by 11.6 °C. Find the enthalpy change of combustion in kJ mol^{-1}. (4 marks)

19. Given standard enthalpies of formation: $CH_4(g)$ -74.8, $CO_2(g)$ -393.5, $H_2O(l)$ -285.8 kJ mol^{-1}, find the standard enthalpy change of $CH_4(g) + 2O_2(g) \rightarrow CO_2(g) + 2H_2O(l)$. (4 marks)

20. Given bond energies: H—H 436, Cl—Cl 243, H—Cl 431 kJ mol^{-1}, find the enthalpy change of $H_2(g) + Cl_2(g) \rightarrow 2HCl(g)$. (3 marks)

F. Molar Volume and Solution Preparation (16 marks)

Take the molar volume as 24.0 dm³ mol^{-1} at room temperature and 22.4 dm³ mol^{-1} at s.t.p.

21. 25.0 g of calcium carbonate (Mr 100) reacts completely with excess dilute hydrochloric acid. Find the volume of carbon dioxide produced at room temperature. (4 marks)

22. Find the mass of 4.48 dm³ of carbon dioxide at s.t.p. (Mr 44.0) (4 marks)

23. What mass of $Na_2CO_3 \cdot 10H_2O$ (Mr 286) is needed to prepare 250.0 cm³ of 0.200 M sodium carbonate solution? (4 marks)

24. 100 cm³ of 2.00 M solution is diluted to 500 cm³, then 25.0 cm³ of it is diluted to 100 cm³. Find the concentration after each dilution. (4 marks)