S5 Chemistry Practice Paper

S5 | Chemistry | Time: 75 minutes | Total: 100 marks | 24 questions

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Part A: Acid-Base Titration and pH (17 marks)

Answer all 4 questions. Volumes are in cm3; show mole calculations.

1. 25.0 cm3 of 0.125 M sodium hydroxide is completely neutralised by 0.1 M hydrochloric acid. Find the moles of NaOH and the volume of acid required.

2. A 0.1 M ethanoic acid solution has Ka = 1.8e-05. Find the hydrogen ion concentration and pH, and explain why the pH is higher than that of hydrochloric acid of the same concentration.

3. 10.0 cm3 of 0.5 M solution is diluted with water to 250 cm3. Find the new concentration and state how many pH units a strong acid would rise by.

4. 0.1 M hydrochloric acid titrates 25.0 cm3 of sodium hydroxide of unknown concentration; the three titres are 22.4, 22.35 and 22.45 cm3. Find the mean titre, moles of NaOH and its concentration, and state the phenolphthalein end point colour change.

Part B: Redox and Electrolysis (17 marks)

Answer all 4 questions. Charge in coulombs; Faraday constant 96500 C mol-1.

5. Acidified potassium permanganate titrates 25.0 cm3 of iron(II) solution, using 18.50 cm3 of 0.02 M KMnO4. Given MnO4- + 8H+ + 5e- -> Mn2+ + 4H2O, find the moles and concentration of Fe2+.

6. Copper(II) sulphate solution is electrolysed at 2.0 A for 30 minutes. Find the charge passed, moles of electrons and mass of copper deposited at the cathode (Cu = 63.5).

7. A cell has a standard EMF of 1.1 V with 2 electrons transferred. Find the standard Gibbs free energy change in kJ mol-1 and explain the meaning of a negative value.

8. State the oxidation number of manganese in MnO4- and explain why KMnO4 is a stronger oxidising agent in acidic solution (hint: the half equation contains 8H+).

Part C: Reaction Rate and Catalysis (17 marks)

Answer all 4 questions. State units clearly.

9. A reaction has an initial rate of 0.02 mol dm-3 s-1 at 0 C and 0.06 mol dm-3 s-1 at 20 C. Find the factor by which the rate rises per 10 K and comment on its temperature sensitivity.

10. Carbon-14 has a half-life of 5730 years. Find the first-order decay constant in year-1 and the fraction remaining after 11460 years.

11. A reaction has an activation energy of 50 kJ mol-1 and its rate constant is measured at 300 K and 310 K. Use the Arrhenius equation to estimate the factor increase (R = 8.314 J K-1 mol-1).

12. In an experiment, with [B] fixed, raising [A] from 0.10 to 0.20 M raises the initial rate from 0.005 to 0.01 mol dm-3 s-1; with [A] fixed, doubling [B] does not change the rate. Find the orders in A and B, the overall order and the rate equation.

Part D: Chemical Equilibrium (17 marks)

Answer all 4 questions. State units for equilibrium constants where they apply.

13. For H2(g) + I2(g) <=> 2HI(g) with initial [H2] = [I2] = 1.00 M and equilibrium [HI] = 1.56 M, find the equilibrium concentrations of H2 and I2 and Kc.

14. For N2(g) + 3H2(g) <=> 2NH3(g) with initial [NH3] = 0.500 M and equilibrium [N2] = 0.0200 M, find the equilibrium concentrations of NH3 and H2 and Kc, and explain why high pressure favours ammonia.

15. A reaction has Kc = 4.0 at a given temperature and the reaction quotient is Q = 2.0 at one moment. Decide the direction of net change and state the rule comparing Q with Kc.

16. A buffer contains equal moles of CH3COOH and CH3COO- with pKa = 4.76. Find the pH and explain why adding a little strong acid changes it only slightly.

Part E: Organic Chemistry and Polymers (16 marks)

Answer all 4 questions. Relative atomic masses: C = 12, H = 1, O = 16.

17. A hydrocarbon contains 85.7% carbon and 14.3% hydrogen. Find its empirical formula and, given a relative molecular mass of 42, its molecular formula.

18. An addition polymer is made from a monomer of relative molecular mass 42 with a number-average degree of polymerisation of 2,500. Find the polymer Mr and state two differences between addition and condensation polymerisation.

19. 0.2 mol of a carboxylic acid is esterified with excess ethanol; the theoretical yield is 17.6 g and 12.3 g is obtained. Find the percentage yield and suggest two ways to raise it.

20. State the number of structural isomers of C4H10 and explain why C4H10 has only 2 while C4H9OH has more.

Part F: Enthalpy Change and Combustion Energy (16 marks)

Answer all 4 questions. Specific heat capacity of water is 4.18 J g-1 K-1.

21. Burning 0.500 g of ethanol heats 200 g of water by 20.7 °C. Find the heat absorbed by the water and the enthalpy of combustion in kJ mol-1 (ethanol Mr = 46).

22. Given standard enthalpies of formation: CO2(g) = -393.5, H2O(l) = -285.8 and CH4(g) = -74.8 kJ mol-1, use Hess law to find the standard enthalpy of combustion of methane.

23. Estimate the enthalpy of CH4 + 2O2 -> CO2 + 2H2O from bond enthalpies: C-H = 413, O=O = 498, C=O = 799 and O-H = 463 kJ mol-1. Find DH and explain the difference from the accepted value.

24. The molar enthalpies of combustion of hydrogen and methane are about -286 and -890 kJ mol-1. Compare them per gram (H2 Mr = 2, CH4 Mr = 16), say which is the better fuel and give one storage difficulty.
