S4 Chemistry Practice Paper: Moles and Molar Volume, Enthalpy of Combustion and Neutralisation, Reaction Rate and Catalysts, Electrolysis and Electroplating, Titration and pH, Redox and Chemical Cells

S4 | Chemistry | Time: 75 minutes | Total: 100 marks | 24 questions

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Moles and Molar Volume

Part A: Mole calculations and molar volume (16 marks)

1. How many moles are there in 8.8 g of carbon dioxide (molar mass 44 g/mol)? [4]

Answer: n = m/M = 8.8/44 = 0.20 mol.

2. A gas has a molar volume of 24 dm^3/mol at room temperature and pressure. Find the volume of 0.20 mol of it. [4]

Answer: V = 0.20 x 24 = 4.8 dm^3 (4800 cm^3).

3. How many oxygen molecules are there in 3.2 g of oxygen (molar mass 32 g/mol)? (Avogadro constant 6.02 x 10^23) [4]

Answer: n = 3.2/32 = 0.10 mol, so the number of molecules = 0.10 x 6.02 x 10^23 = 6.02 x 10^22.

4. 0.25 mol of sodium chloride is dissolved in water to make 500 cm^3 of solution. Find the molarity. [4]

Answer: Molarity = 0.25/0.500 = 0.50 mol/dm^3.

Enthalpy Changes

Part B: Enthalpy of combustion and neutralisation (16 marks)

5. Burning 0.10 mol of methanol releases 72.6 kJ of energy. Find the enthalpy change of combustion of methanol in kJ/mol. [4]

Answer: Energy released per mole = 72.6/0.10 = 726 kJ, so dHc = -726 kJ/mol.

6. Water of mass 4.2 g is heated through 10 degrees C (specific heat capacity of water 4.2 J g^-1 K^-1). Find the energy needed. [4]

Answer: E = mc dT = 4.2 x 4.2 x 10 = 176 J (about 0.18 kJ).

7. Burning 1.0 g of a fuel raises 100 g of water from 25 degrees C to 35 degrees C. Find the energy released per gram of fuel. [4]

Answer: E = 100 x 4.2 x 10 = 4200 J, i.e. 4.2 kJ per gram of fuel.

8. 50 cm^3 of 1.0 M hydrochloric acid is mixed with 50 cm^3 of 1.0 M sodium hydroxide and the temperature rises by 6.0 degrees C. Find the enthalpy change of neutralisation (assume the solution has the density and specific heat capacity of water). [4]

Answer: Heat released = 100 x 4.2 x 6.0 = 2520 J; water formed = 0.050 mol; dH = -2520/0.050 J/mol = -50 kJ/mol (about -50.4 kJ/mol).

Reaction Rate

Part C: Reaction rate and catalysts (17 marks)

9. In a reaction the amount of a reactant falls from 0.50 mol to 0.10 mol in 20 s. Find the average rate of reaction in mol/s. [4]

Answer: Rate = (0.50 - 0.10)/20 = 0.020 mol/s.

10. A reaction is first order with respect to reactant A. If the concentration of A is doubled, by what factor does the rate change? [4]

Answer: For a first order reaction the rate is proportional to concentration, so doubling it doubles the rate (factor of 2).

11. How does a catalyst affect the rate of a reaction and its enthalpy change? [4]

Answer: A catalyst provides an alternative route of lower activation energy and so speeds up the reaction, but it does not change the energies of reactants and products, so the enthalpy change is unchanged.

12. For a gas reaction the rate roughly doubles for every 10 degrees C rise in temperature. If the temperature rises from 300 K to 330 K, by what factor does the rate change? [5]

Answer: A rise of 30 degrees C is three intervals of 10 degrees C, so the rate becomes about 2^3 = 8 times the original.

Electrolysis and Plating

Part D: Electrolysis and electroplating (17 marks)

13. Copper(II) sulphate solution is electrolysed with a current of 2.0 A for 965 s. Find the mass of copper deposited at the cathode (molar mass of Cu = 63.5 g/mol, 1 F = 96500 C). [5]

Answer: Charge = 2.0 x 965 = 1930 C; electrons = 1930/96500 = 0.020 mol; Cu2+ needs 2 electrons, so Cu = 0.010 mol; mass = 0.010 x 63.5 = 0.64 g.

14. Water acidified with dilute sulphuric acid is electrolysed using 4 F of charge. Find the amount in moles of the products at the anode and at the cathode. [4]

Answer: Anode: 4OH- gives O2 + 2H2O + 4e-, so 1 mol of O2; cathode: 4H+ + 4e- gives 2H2, so 2 mol of H2.

15. Silver plating deposits 1.08 g of silver (molar mass 108 g/mol). If the current is 1.0 A, find the time needed. [4]

Answer: Ag = 1.08/108 = 0.010 mol, requiring 0.010 F = 965 C; t = Q/I = 965/1.0 = 965 s.

16. When concentrated sodium chloride solution is electrolysed, what is formed at the anode and at the cathode, and is the remaining solution acidic, neutral or alkaline? [4]

Answer: Chlorine at the anode (2Cl- gives Cl2 + 2e-) and hydrogen at the cathode (2H2O + 2e- gives H2 + 2OH-); the hydroxide ions make the solution alkaline.

Titration and pH

Part E: Titration and pH (17 marks)

17. 25.0 cm^3 of sodium hydroxide solution is titrated with 0.100 M hydrochloric acid; 20.0 cm^3 of the acid is used. Find the concentration of the sodium hydroxide. [4]

Answer: The mole ratio is 1 : 1, so c = 0.100 x 20.0/25.0 = 0.080 M.

18. A solution has a hydrogen ion concentration of 1.0 x 10^-3 M. Find its pH. [4]

Answer: pH = -log[H+] = -log(1.0 x 10^-3) = 3.

19. 10 cm^3 of 0.10 M hydrochloric acid is diluted with water to 100 cm^3. Find the pH of the diluted solution. [4]

Answer: Diluting ten times gives 0.010 M, so pH = 2.

20. What volume of 0.20 M sulphuric acid is needed to neutralise 25 cm^3 of 0.10 M sodium hydroxide? [5]

Answer: NaOH = 0.025 x 0.10 = 0.0025 mol, so H2SO4 needed = 0.00125 mol; V = 0.00125/0.20 = 0.00625 dm^3 = 6.25 cm^3.

Redox and Cells

Part F: Redox and chemical cells (17 marks)

21. In a zinc-copper cell, in which direction do electrons flow, and which electrode is the negative terminal? [4]

Answer: Zinc is more reactive and is oxidised to Zn2+, releasing electrons, so zinc is the negative terminal and electrons flow from zinc to copper through the external circuit.

22. Find the oxidation number of manganese in potassium manganate(VII), KMnO4. [4]

Answer: K is +1 and four O give -8, so Mn = +7.

23. How many electrons are lost when an iron atom becomes Fe3+, and is the iron oxidised or reduced? [4]

Answer: Fe gives Fe3+ + 3e-, losing 3 electrons; the oxidation number rises from 0 to +3, so it is oxidised.

24. A battery is rated at 3000 mAh. If it discharges at 3.0 A, how many coulombs does it supply? [5]

Answer: 3000 mAh = 3.0 A x 3600 s = 10800 C (about 1.1 x 10^4 C).