S5 Chemistry Practice Paper (Set 3): Rates of Reaction and Collision Theory, Chemical Equilibrium and the Equilibrium Constant, Weak Acid pH and Titration Curves, Electrolysis and Faraday Calculations, Enthalpy Change and Hess Law, Redox Titration

S5 Chemistry | 100 marks | 75 minutes

Question 1: Rates of Reaction and Collision Theory

Excess marble chips (calcium carbonate) are added to 50.0 cm3 of 1.0 M hydrochloric acid at 25 degrees Celsius. The volume of carbon dioxide collected is 0 cm3 at 0 s, 48 cm3 at 20 s, 72 cm3 at 40 s, 86 cm3 at 60 s, 94 cm3 at 80 s, 98 cm3 at 100 s and 98 cm3 at 120 s.

Calculate the average rate of reaction over the first 40 seconds in cm3 per second. *(5 marks)*

Compare the average rate in the first 20 s with that between 20 s and 40 s, and explain the difference. *(4 marks)*

If the same mass of marble is used as a powder, how does the curve change? Does the final gas volume change? *(4 marks)*

Suggest two ways to speed up this reaction without changing the final gas volume, and explain why. *(3 marks)*

Question 2: Chemical Equilibrium and the Equilibrium Constant

Nitrogen and hydrogen are sealed in a container at 500 degrees Celsius: N2(g) + 3H2(g) <-> 2NH3(g), delta H = -92 kJ per mole. At equilibrium [N2] = 0.50 M, [H2] = 0.30 M and [NH3] = 0.40 M.

Write the expression for the equilibrium constant Kc and calculate its value and unit. *(5 marks)*

At the same temperature the container volume is halved. How do the position of equilibrium and Kc change? *(4 marks)*

The temperature is raised to 600 degrees Celsius. How do Kc and the equilibrium yield of ammonia change? Explain. *(4 marks)*

What effect does adding an iron catalyst have on Kc and on the position of equilibrium? *(4 marks)*

Question 3: Weak Acid pH and Titration Curves

At 25 degrees Celsius, 25.0 cm3 of 0.100 M ethanoic acid (CH3COOH, Ka = 1.8 x 10^-5 mol dm^-3) is titrated with 0.100 M sodium hydroxide solution.

Calculate the pH of the acid before any alkali is added. *(4 marks)*

Calculate the volume of sodium hydroxide needed to reach the equivalence point. *(3 marks)*

Calculate the pH at the equivalence point (salt concentration 0.050 M). *(5 marks)*

Which indicator should be used? Explain. *(5 marks)*

Question 4: Electrolysis and Faraday Calculations

A steady current of 2.0 A is passed through copper(II) sulphate solution for 30 minutes (1 F = 96500 C per mole, Cu = 63.5, molar volume 24.0 dm3 per mole at room temperature).

Calculate the quantity of charge passed and the number of moles of electrons. *(5 marks)*

With copper as the cathode, calculate the mass gained at the cathode. *(5 marks)*

If inert electrodes are used to electrolyse dilute sulphuric acid, calculate the volume of oxygen released at the anode in cm3. *(4 marks)*

To electroplate 0.200 mol of silver at 5.0 A, how many seconds are needed? *(3 marks)*

Question 5: Enthalpy Change and Hess Law

Standard enthalpies of formation: CO2(g) -394, H2O(l) -286, C2H5OH(l) -277 and CO(g) -111 kJ per mole. Specific heat capacity of water is 4.2 J per gram per kelvin and the molar mass of ethanol is 46.0 g per mole.

Calculate the standard enthalpy of combustion of ethanol. *(5 marks)*

How much energy is released by burning 4.6 g of ethanol? *(5 marks)*

If all this energy heats water from 25 to 65 degrees Celsius, what mass of water can be heated? *(4 marks)*

Use Hess law to find delta H for CO(g) + H2O(l) -> CO2(g) + H2(g), and state why the experimental value is often less exothermic than the theoretical one. *(3 marks)*

Question 6: Redox Titration

25.0 cm3 of iron(II) sulphate solution is titrated with 0.0200 M acidified potassium manganate(VII) solution, mean titre 24.0 cm3. The same iron(II) solution is then used to titrate 25.0 cm3 of 0.0167 M potassium dichromate solution.

Write the balanced ionic equation and find the concentration of the iron(II) solution. *(5 marks)*

State the changes in oxidation number of manganese and iron. *(3 marks)*

Why is no extra indicator needed in this titration? *(4 marks)*

Calculate the volume of iron(II) solution needed to titrate 25.0 cm3 of the dichromate solution. *(4 marks)*