S5 Chemistry Practice Paper | mole and concentration, acid-base titration, electrolysis and charge, reaction rate, neutralisation enthalpy, molar volume

Senior Secondary Chemistry

S5 Chemistry practice paper with answers: molar mass, titration, electrolysis and charge, reaction rate and temperature, neutralisation enthalpy and molar gas volume.

Question 1 Molar mass and concentration

5.30 g of anhydrous sodium carbonate (Na2CO3) is dissolved in distilled water and made up to 250 cm3 in a volumetric flask. (Relative atomic masses: Na = 23.0, C = 12.0, O = 16.0)

#	Question	Answer and marking notes
1	(a) Find the molar mass of Na2CO3 and the number of moles in 5.30 g.	Answer: molar mass = 106 g/mol, moles = 5.30 / 106 = 0.050 mol.
2	(b) Find the concentration of the solution in mol/dm3.	Answer: 0.050 / 0.250 = 0.200 mol/dm3.
3	(c) 25.0 cm3 of the solution is taken. Find the number of moles of sodium ions.	Answer: Na2CO3 = 0.200 x 0.0250 = 0.0050 mol, so Na+ = 0.0100 mol.
4	(d) To prepare 500 cm3 of 0.100 mol/dm3 solution, what mass of Na2CO3 is needed? State one key step when making up to the mark.	Answer: 0.050 mol gives 5.30 g; make up to the 500 cm3 mark and mix, rather than adding 500 cm3 of water.

Question 2 Titration with sodium carbonate

25.0 cm3 of 0.100 mol/dm3 sodium carbonate standard solution is titrated with hydrochloric acid of unknown concentration; 24.0 cm3 of the acid is needed for complete neutralisation. Na2CO3 + 2HCl gives 2NaCl + H2O + CO2.

#	Question	Answer and marking notes
5	(a) Find the moles of sodium carbonate and the concentration of the acid.	Answer: 0.0025 mol of Na2CO3 gives 0.0050 mol of HCl, so c = 0.21 mol/dm3.
6	(b) If 0.150 mol/dm3 acid is used instead, what volume is needed for the same aliquot?	Answer: 0.0050 mol / 0.150 = 33.3 cm3.
7	(c) If the acid is added only to the first equivalence point (forming NaHCO3), what volume is needed?	Answer: only 0.0025 mol, giving 12.0 cm3.
8	(d) If the pipette is rinsed with distilled water but not with the carbonate solution, how is the calculated acid concentration affected?	Answer: residual water dilutes the aliquot, less carbonate is present, the titre is smaller, so the calculated acid concentration is too low.

Question 3 Electrolysis and quantity of charge

A current of 2.00 A is passed through copper(II) sulphate solution for 30.0 minutes. (Faraday constant 96500 C/mol, Cu = 63.5, Ag = 108)

#	Question	Answer and marking notes
9	(a) Find the quantity of charge passed and the moles of electrons.	Answer: Q = 2.00 x 1800 = 3600 C, giving 0.0373 mol of electrons.
10	(b) The cathode reaction is Cu2+ + 2e- gives Cu. Find the mass of copper deposited.	Answer: 0.0187 mol of Cu, that is 1.18 g.
11	(c) With the same charge, what mass of silver is deposited from silver nitrate solution?	Answer: 0.0373 mol, that is 4.03 g of silver.
12	(d) At 3.00 A, how long is needed to deposit 3.175 g of copper?	Answer: 0.1000 mol of electrons need 9650 C, so about 53.6 minutes.

Question 4 Rate of reaction and temperature

Magnesium reacts with dilute hydrochloric acid and the hydrogen is collected. 48.0 cm3 is collected in the first 40 s; the reaction finishes in 120 s with 168 cm3 in total.

#	Question	Answer and marking notes
13	(a) Find the average rate over the first 40 s in cm3/s.	Answer: 48.0 / 40 = 1.20 cm3/s.
14	(b) Find the average rate for the whole reaction and explain the higher initial rate.	Answer: 168 / 120 = 1.40 cm3/s; the acid concentration, and hence the collision frequency, is highest at the start.
15	(c) Replacing the magnesium ribbon with the same mass of magnesium powder, how does the rate change? Explain.	Answer: much faster, because the larger surface area exposes more particles to the acid, raising the collision frequency; the total volume of gas is unchanged.
16	(d) The rate roughly doubles for every 10 C rise. From 20 C to 40 C, by what factor does the rate increase and what is the new completion time?	Answer: 4 times faster, so about 30 s.

Question 5 Enthalpy of neutralisation

50.0 cm3 of 1.00 mol/dm3 hydrochloric acid is mixed with 50.0 cm3 of 1.00 mol/dm3 sodium hydroxide in a polystyrene cup; the temperature rises from 25.0 C to 31.8 C. Assume a density of 1.00 g/cm3 and a specific heat capacity of 4.2 J/(g C).

#	Question	Answer and marking notes
17	(a) Find the heat released in kJ.	Answer: 100 x 4.2 x 6.8 = 2856 J, that is 2.856 kJ.
18	(b) Find the molar enthalpy change of neutralisation.	Answer: 0.0500 mol of water formed, so the enthalpy change is -57.1 kJ/mol.
19	(c) If 0.50 mol/dm3 acid and alkali are used instead, what temperature rise is expected?	Answer: about 3.4 C, since half as many moles react.

#	Question	Answer and marking notes
20	(d) Replacing the acid with ethanoic acid of the same concentration and volume, would the magnitude of the enthalpy change be larger or smaller? Explain.	Answer: smaller, because a weak acid is only partly ionised and ionising the rest absorbs energy, so less net heat is released.

Question 6 Molar volume of gases

At room temperature and pressure the molar volume of a gas is 24.0 dm3/mol. (C = 12.0, O = 16.0, Mg = 24.0)

#	Question	Answer and marking notes
21	(a) Find the moles and mass of 4.80 dm3 of carbon dioxide at room conditions.	Answer: 0.200 mol, that is 8.80 g.
22	(b) 6.00 g of magnesium reacts completely with excess dilute acid. Find the volume of hydrogen at room conditions.	Answer: 0.250 mol of H2, that is 6.00 dm3.
23	(c) 2.00 mol of nitrogen is mixed with 3.00 mol of oxygen. Find the total volume at room conditions and the mole fraction of nitrogen.	Answer: 5.00 mol in total gives 120 dm3, with a nitrogen mole fraction of 0.400.
24	(d) What volume would the same 0.200 mol of gas occupy at s.t.p., where the molar volume is 22.4 dm3/mol?	Answer: 4.48 dm3, smaller than 4.80 dm3 because the temperature is lower.