S3 Chemistry Practice Paper 2 | Atomic structure, bonding and formulae, mole calculations, concentration, titration, metal reactivity

Junior Secondary Chemistry

S3 Chemistry practice paper 2 with worked solutions: atomic structure, isotopes, bonding, formula mass, mole calculations, titration and metal reactivity.

1. Atomic structure and isotopes (16 marks)

The atomic number of element X is 17. In nature X exists as two isotopes with mass numbers 35 and 37 and abundances of 75 per cent and 25 per cent. An atom of element Y contains 12 protons and 12 neutrons.

#	Question	Answer and marking notes
1	(a) Write the electronic arrangement of element X by shells, and state the period and group to which it belongs.	Answer: an atomic number of 17 means 17 electrons, arranged 2, 8, 7; with 7 electrons in the outermost shell, X is in Period 3, Group 17, a halogen.
2	(b) Calculate the number of neutrons in each of the two isotopes.	Answer: neutrons = mass number minus proton number; the isotope of mass number 35 has 35 - 17 = 18 neutrons and the isotope of mass number 37 has 37 - 17 = 20 neutrons.
3	(c) Calculate the relative atomic mass of element X, correct to one decimal place.	Answer: relative atomic mass = 35 x 75 per cent + 37 x 25 per cent = 26.25 + 9.25 = 35.5.
4	(d) What is the mass number of element Y, and how many electrons are in its outermost shell?	Answer: mass number = protons + neutrons = 12 + 12 = 24; Y is magnesium, arranged 2, 8, 2, so its outermost shell holds 2 electrons.

2. Chemical bonding and formulae (16 marks)

The following substances are held together by different types of bonding: sodium chloride (NaCl), sodium sulphate (Na2SO4), aluminium oxide (Al2O3), methane (CH4) and carbon dioxide (CO2). Relative atomic masses: Na 23, Al 27, S 32, O 16, C 12, H 1.

#	Question	Answer and marking notes
5	(a) State the type of bonding in NaCl and in CH4, and explain how each is formed.	Answer: in NaCl a metal transfers electrons to a non-metal, giving ionic bonding; in CH4 carbon and hydrogen share pairs of electrons, giving covalent bonding.
6	(b) Write the formula of the compound formed from Na+ and SO4 2-, and explain your answer.	Answer: the formula is Na2SO4; each sulphate ion carries 2 negative charges, so 2 sodium ions, each with 1 positive charge, are needed to balance the charge.
7	(c) Write the formula of the compound formed from Al3+ and O2-, and justify it by charges.	Answer: the formula is Al2O3; 2 Al3+ ions supply 6 positive charges and 3 O2- ions supply 6 negative charges, so the charges cancel.
8	(d) Calculate the relative formula mass of Na2SO4 and the relative molecular mass of CO2.	Answer: Na2SO4 = 23 x 2 + 32 + 16 x 4 = 142; CO2 = 12 + 16 x 2 = 44.

3. Formula mass and mole calculations (18 marks)

Relative atomic masses: C 12, O 16, Na 23, H 1. Take the Avogadro constant as 6.02 x 10 to the power 23.

#	Question	Answer and marking notes
9	(a) How many moles are there in 4.4 g of carbon dioxide?	Answer: moles = mass divided by molar mass = 4.4 / 44 = 0.1 mol.
10	(b) How many molecules are there in that 4.4 g of carbon dioxide?	Answer: number of molecules = 0.1 x 6.02 x 10 to the power 23 = 6.02 x 10 to the power 22.
11	(c) What is the mass of 0.25 mol of sodium carbonate (Na2CO3)?	Answer: molar mass = 23 x 2 + 12 + 16 x 3 = 106 g/mol; mass = 0.25 x 106 = 26.5 g.
12	(d) 8.0 g of sodium hydroxide is dissolved in water to make 500 cm3 of solution. Find its molar concentration.	Answer: moles = 8.0 / 40 = 0.2 mol; volume = 500 cm3 = 0.500 dm3; concentration = 0.20 / 0.500 = 0.4 mol/dm3.

4. Solution concentration and dilution (18 marks)

A laboratory keeps 2.0 mol/dm3 hydrochloric acid as a stock solution. Separately, 20 g of a solute of molar mass 40 g/mol is dissolved completely in water to make 2.0 dm3 of solution.

#	Question	Answer and marking notes
13	(a) 250 cm3 of a solution contains 0.050 mol of solute. Find its molar concentration.	Answer: 250 cm3 = 0.250 dm3; concentration = 0.050 / 0.250 = 0.2 mol/dm3.
14	(b) 25.0 cm3 of 2.0 mol/dm3 hydrochloric acid is diluted to 0.50 mol/dm3. What is the final volume, and how much water must be added?	Answer: C1V1 = C2V2, so 2.0 x 25.0 = 0.50 x V2 and V2 = 100 cm3; the water added is 75 cm3.
15	(c) Find the molar concentration and the mass concentration in g/dm3 of the 20 g solute solution described above.	Answer: moles = 20 / 40 = 0.5 mol; molar concentration = 0.50 / 2.0 = 0.25 mol/dm3; mass concentration = 20 / 2.0 = 10 g/dm3.
16	(d) A solution has a mass concentration of 4.0 g/dm3 and the solute has a molar mass of 40 g/mol. Find the molar concentration.	Answer: molar concentration = 4.0 / 40 = 0.10 mol/dm3.

5. Acid-base neutralisation and titration (16 marks)

25.0 cm3 of sodium hydroxide solution is titrated with 0.10 mol/dm3 hydrochloric acid, and 20.0 cm3 of the acid is used to reach the end point. HCl + NaOH -> NaCl + H2O.

#	Question	Answer and marking notes
17	(a) Calculate the molar concentration of the sodium hydroxide solution.	Answer: moles of acid = 0.10 x 0.0200 = 0.0020 mol; HCl and NaOH react in a 1 : 1 ratio, so there are 0.0020 mol of NaOH; concentration = 0.0020 / 0.0250 = 0.080 mol/dm3.
18	(b) How many moles of sodium hydroxide are needed to neutralise 0.050 mol of sulphuric acid?	Answer: H2SO4 + 2NaOH -> Na2SO4 + 2H2O, a ratio of 1 : 2, so NaOH needed = 0.050 x 2 = 0.10 mol.

#	Question	Answer and marking notes
19	(c) A hydrochloric acid solution has a concentration of 0.010 mol/dm3. Find its pH.	Answer: the strong acid is fully ionised, so [H+] = 0.010 mol/dm3 and pH = -log(0.010) = 2.
20	(d) What volume of 0.050 mol/dm3 sulphuric acid is needed to neutralise 20.0 cm3 of 0.10 mol/dm3 sodium hydroxide?	Answer: moles of NaOH = 0.10 x 0.0200 = 0.0020 mol; H2SO4 needed = 0.0020 / 2 = 0.0010 mol; volume = 0.0010 / 0.050 = 0.020 dm3 = 20 cm3.

6. Metal reactivity and yield calculations (16 marks)

2.6 g of zinc (relative atomic mass 65) is added to excess copper(II) sulphate solution and copper (relative atomic mass 64) is formed. Zn + CuSO4 -> ZnSO4 + Cu.

#	Question	Answer and marking notes
21	(a) Arrange potassium, sodium, magnesium and copper in order of reactivity with water and dilute acid, from most to least reactive, giving one observation for each.	Answer: potassium, then sodium, then magnesium, then copper; potassium reacts violently with cold water and floats, sodium reacts violently with cold water and melts into a ball, magnesium needs hot water or dilute acid, and copper does not react with dilute acid.
22	(b) Calculate the theoretical mass of copper that 2.6 g of zinc can produce.	Answer: moles of zinc = 2.6 / 65 = 0.04 mol; zinc and copper are in a 1 : 1 ratio, so copper is also 0.040 mol; mass of copper = 0.040 x 64 = 2.56 g.
23	(c) The experiment gives only 2.30 g of copper. Calculate the percentage yield, correct to one decimal place.	Answer: yield = actual mass divided by theoretical mass x 100 per cent = 2.30 / 2.56 x 100 per cent = 89.8 per cent.
24	(d) Explain why copper does not react with dilute hydrochloric acid.	Answer: copper lies below hydrogen in the reactivity series, so it cannot reduce hydrogen ions to hydrogen gas and does not react with dilute hydrochloric acid.