S5 Chemistry Practice Paper 2 | Atomic structure, bonding, titration, equilibrium, electrolysis and organic chemistry

Senior Secondary Chemistry

S5 Chemistry practice paper 2 with worked solutions covering atomic structure, bonding, titration, equilibrium, electrolysis and organic chemistry.

1. Atomic structure and periodicity (18 marks)

Show your reasoning; give the relative atomic mass to 3 decimal places.

#	Question	Answer and marking notes
1	(a) State the number of protons, neutrons and electrons in the sulfide ion 32S2-.	Sulfur has atomic number 16 and mass number 32: 16 protons, 32 - 16 = 16 neutrons; the 2- charge adds 2 electrons, so 16 + 2 = 18 electrons.
2	(b) An element has the electron configuration 1s2 2s2 2p6 3s2 3p5. State its period and group.	The outermost shell is n = 3, so period 3; there are 2 + 5 = 7 valence electrons, so group 17 (the halogens).
3	(c) Explain why the first ionisation energy of magnesium is higher than that of aluminium.	Magnesium loses a 3s electron whereas aluminium loses a 3p electron. The 3p orbital is higher in energy and is shielded by the 3s electrons, so aluminium loses its electron more easily and has the lower first ionisation energy.
4	(d) Copper consists of 69.2% Cu-63 and 30.8% Cu-65. Calculate its relative atomic mass.	Relative atomic mass = 63 x 0.692 + 65 x 0.308 = 63.616.

2. Chemical bonding and structure (16 marks)

Your explanations must refer to electron pairs and molecular shape.

#	Question	Answer and marking notes
5	(a) Use VSEPR theory to state the shapes and approximate bond angles of NH3 and H2O.	NH3 has 3 bonding pairs and 1 lone pair, giving a trigonal pyramidal shape with a bond angle of about 107 degrees; H2O has 2 bonding pairs and 2 lone pairs, giving a bent shape with a bond angle of about 104.5 degrees.
6	(b) Decide whether CO2, H2O and NH3 are polar molecules and give brief reasons.	CO2 is linear, so its two C=O dipoles cancel and it is non-polar; H2O (bent) and NH3 (trigonal pyramidal) have dipoles that do not cancel, so both are polar.
7	(c) Compare the structure types and melting points of NaCl, SiO2 and I2.	NaCl has a giant ionic lattice, SiO2 a giant covalent structure and I2 a simple molecular structure; melting point SiO2 > NaCl > I2 (covalent bonds > ionic bonds > van der Waals forces).
8	(d) Each water molecule in ice forms 4 hydrogen bonds. Calculate the number of hydrogen bonds in 1 mol of ice.	Number of hydrogen bonds = 4 x 6.022 x 10^23 = 2.409 x 10^24 (each bond is shared by two molecules, so 1 mol of water gives 2 mol of hydrogen bonds).

3. Moles, concentration and titration (16 marks)

Show the working and units; give answers to 3 significant figures.

#	Question	Answer and marking notes
9	(a) 25.0 cm3 of 0.100 M NaOH is completely neutralised by 0.0500 M H2SO4. Find the volume of acid required.	Moles of NaOH = 0.100 x 0.0250 = 0.00250 mol; from H2SO4 + 2NaOH -> Na2SO4 + 2H2O, acid needed = 0.00125 mol; volume = 0.00125 / 0.0500 = 0.0250 dm3 = 25.0 cm3.
10	(b) Calculate the number of moles in 5.85 g of sodium chloride (M = 58.5 g/mol).	Moles = 5.85 / 58.5 = 0.100 mol.
11	(c) 50.0 cm3 of 2.00 M hydrochloric acid is diluted with water to 250 cm3. Find the new concentration.	C1V1 = C2V2, so C2 = 2.00 x 50.0 / 250 = 0.400 M.
12	(d) A reaction has a theoretical yield of 12.0 g but gives 9.60 g. Find the percentage yield.	Percentage yield = 9.60 / 12.0 x 100% = 80.0% .

4. Reaction rates and chemical equilibrium (18 marks)

Show how the orders are deduced and give units.

#	Question	Answer and marking notes
13	(a) Doubling [A] quadruples the rate, while doubling [B] has no effect. Write the rate equation and state the order with respect to A and B.	The rate is proportional to [A]^2, so the reaction is second order in A; changing [B] has no effect, so it is zero order in B. Rate = k[A]^2.
14	(b) For H2(g) + I2(g) <=> 2HI(g), [H2] = [I2] = 1.00 M initially and [HI] = 1.60 M at equilibrium. Find Kc.	Making 1.60 M HI uses 0.80 M of each reactant, so [H2] = [I2] = 0.20 M at equilibrium; Kc = 1.60^2 / (0.20 x 0.20) = 64.0.
15	(c) For N2(g) + 3H2(g) <=> 2NH3(g) (delta H < 0), state the effect of increasing pressure and of raising temperature on the position of equilibrium.	Increasing pressure shifts the equilibrium towards the side with fewer gas moles (right, more NH3); raising the temperature shifts it in the endothermic direction (left), lowering the NH3 yield.
16	(d) How does a catalyst affect the reaction rate and the equilibrium constant?	A catalyst provides a pathway of lower activation energy and speeds up both forward and reverse reactions equally, so the position of equilibrium and Kc are unchanged.

5. Acids and bases, redox and electrolysis (16 marks)

Give pH to 2 decimal places and other answers to 3 significant figures.

#	Question	Answer and marking notes
17	(a) Find the pH of 0.0100 M HCl and of 0.0100 M NaOH.	HCl is a strong acid, so [H+] = 0.0100 M and pH = 2.00; NaOH is a strong base, so [OH-] = 0.0100 M, pOH = 2.00 and pH = 12.00.
18	(b) Find the pH of 0.100 M CH3COOH (Ka = 1.8 x 10^-5).	[H+] = sqrt(Ka x c) = sqrt(1.8 x 10^-5 x 0.100) = 1.342 x 10^-3 M; pH = 2.87.
19	(c) Find the oxidation number of manganese in KMnO4 and of chromium in K2Cr2O7.	For KMnO4: (+1) + x + 4(-2) = 0, so x = +7; for K2Cr2O7: 2(+1) + 2x + 7(-2) = 0, so x = +6.
20	(d) A current of 2.00 A passes through CuSO4 solution for 30.0 minutes. Find the mass of copper deposited at the cathode (Cu = 63.5).	Charge = 2.00 x 30.0 x 60 = 3600 C; moles of electrons = 3600 / 96500 = 0.03731 mol; Cu2+ + 2e- -> Cu, so mass = 0.03731 / 2 x 63.5 = 1.1845 g.

6. Organic chemistry: functional groups and isomerism (16 marks)

Give names or structural formulae.

#	Question	Answer and marking notes
21	(a) Name the functional group present in ethanol, ethanoic acid, ethyl ethanoate and propanone.	Ethanol: hydroxyl (-OH); ethanoic acid: carboxyl (-COOH); ethyl ethanoate: ester (-COO-); propanone: carbonyl (ketone, C=O).
22	(b) State the number of structural isomers of C4H10 and of C2H6O.	C4H10 has 2 (butane and 2-methylpropane); C2H6O has 2 (ethanol and methoxymethane).
23	(c) Name the reaction types for converting ethanol to ethene and for heating ethanol with ethanoic acid to form ethyl ethanoate.	Ethanol to ethene is dehydration (elimination) using concentrated sulfuric acid and heat; ethanol with ethanoic acid is esterification (condensation) catalysed by concentrated sulfuric acid.
24	(d) Compare the reaction of ethene and of methane with bromine, and name the product of the ethene reaction.	Ethene undergoes addition with bromine (the double bond opens) to give 1,2-dibromoethane; methane undergoes free-radical substitution under ultraviolet light to give bromomethane and hydrogen bromide.