Neap

Trial Examination 2022

Suggested Solutions

QCE Chemistry Units 1&2

Paper 1

SECTION 1 – MULTIPLE CHOICE QUESTIONS

	A	B	C	D
1.	○	○	●	○
2.	○	○	●	○
3.	○	○	○	●
4.	○	○	●	○
5.	○	●	○	○
6.	○	○	●	○
7.	●	○	○	○
8.	○	○	○	●
9.	○	○	○	●
10.	○	○	●	○
11.	○	●	○	○
12.	●	○	○	○
13.	●	○	○	○
14.	○	●	○	○
15.	●	○	○	○

	A	B	C	D
16.	○	○	●	○
17.	○	●	○	○
18.	●	○	○	○
19.	●	○	○	○
20.	○	○	●	○
21.	○	○	○	●
22.	○	○	○	●
23.	○	○	○	●
24.	○	○	●	○
25.	○	○	●	○

QUESTION 1 C

C is correct. He^+ has one electron.

A, **B** and **D** are incorrect. H^-, Be^{2+} and B^{3+} each have two electrons.

QUESTION 2 C

C is correct. Al_2O_3 is an amphoteric substance; it can react as an acid and a base.

A and **D** are incorrect. SO_2 and SiO_2 are acidic oxides.

B is incorrect. CaO is a basic oxide.

QUESTION 3 D

D is correct. Strontium atoms are larger than magnesium atoms, so the electrons in a strontium atom are further from the attractive pull of the nucleus than the electrons in a magnesium atom. Electrons in a strontium atom are also better shielded as there are more inner shells of electrons.

A is incorrect. Strontium hydroxide is more soluble than magnesium hydroxide.

B is incorrect. Both strontium and magnesium sink in water.

C is incorrect. Strontium atoms have more electron shells than magnesium atoms, so they are larger.

QUESTION 4 C

$$\frac{7(63)+3(65)}{10}=63.60$$

QUESTION 5 B

B is correct. Metals have delocalised electrons.

A is incorrect. Silver atoms are already ionised.

C is incorrect. The metal's crystal lattice does not break down.

D is incorrect. Silver ions vibrate on the spot; they do not move around.

QUESTION 6 C

Electron gain results in a larger radius through electron repulsion, so a 3– ion will have more repulsion than a 1– ion. All the species have the same electronic arrangement (2, 8), but nitrogen (N) has the smallest atomic number; therefore, it has the least number of protons attracting electrons, resulting in a larger radius.

QUESTION 7 A

Equal volumes of gases contain equal numbers of molecules under the same temperature and pressure conditions. Higher temperatures will cause gas molecules to move faster and take up more space. The gas at the lowest temperature (nitrogen, N_2) will therefore have the highest concentration of molecules.

QUESTION 8 D

D is correct. Calcium carbonate is insoluble (as stated in the Formula and Data Booklet), so it will precipitate.

A, **B** and **C** are incorrect. The calcium compounds of these anions are soluble.

QUESTION 9 D

Ionisation energy generally increases across a period because of the increasing nuclear charge. This trend has exceptions; one exception is between groups 15 and 16. In a group 15 element (such as phosphorus), the p electrons are in separate orbitals, which minimises repulsion. The pairing of the electrons in the first p orbital of a group 16 element (such as sulfur) causes repulsion, which increases energy and makes it easier for the outermost electron to be removed. Therefore, phosphorus has a higher first ionisation energy than sulfur. The only option that has elements in groups 14, 15 and 16 consecutively is option **D**.

QUESTION 10 C

C is correct. Silicon is in group 14 in the periodic table. In silicon, the fifth electron is in an inner shell, less shielded and closer to the nucleus, so it is much harder to remove. Thus, the greatest difference is between the fourth and fifth ionisation energies.

A, **B** and **D** are incorrect. These outer four electrons are much easier to remove than the fifth, which is in an inner shell.

QUESTION 11 B

B is correct and **D** is incorrect. When a hydrogen halide decomposes, it produces hydrogen and a halogen. Covalent bond strength decreases down a group as the atoms in a molecule become larger and the shared electron pair is further from the nucleus's pull. Thus, the H–F covalent bond in hydrogen fluoride is stronger than the H–Br bond in hydrogen bromide and is more difficult to break, making it more stable.

A and **C** are incorrect. The covalent bonds in hydrogen fluoride and hydrogen bromide are H–F and H–Br, respectively, not F–F and Br–Br.

QUESTION 12 A

A is correct and **D** is incorrect. Water is a polar solvent and sample A moves furthest in this mobile phase; therefore, sample A has the most polar molecules.

B and **C** are incorrect. These samples do not move as far in the polar solvent.

QUESTION 13 A

A is correct. Since iodine vaporises when heated gently, this means it has weak intermolecular forces in the solid state.

B is incorrect. Molecular solids cannot become ionic vapours.

C is incorrect. An ionic solid would have a high melting point.

D is incorrect. Atoms cannot become molecules when vaporised.

QUESTION 14 B

B is correct. The bond angles are 120° (BH_3), 109° (CH_4) and 107° (NH_3).

A and **C** are incorrect. These options show NH_3 with a larger bond angle than CH_4. Option **A** also shows CO_2 as having the smallest bond angle, but it has a bond angle of 180°.

D is incorrect. The bond angle in BF_3 is 120°.

QUESTION 15 A

A is correct. All solids have a lattice structure.

B and **D** are incorrect. Silicon dioxide has a covalent network.

C is incorrect. Solid carbon dioxide has double covalent bonds.

QUESTION 16 C

According to the kinetic theory, the particles in ideal gases have zero volume and zero attractive forces between them. These qualities are best met by gases at high temperature and low pressure; under these conditions, the particles are further apart and move faster, making the volume that the gas fills greater and resulting in fewer attractions between particles.

QUESTION 17 B

The molar volume of an ideal gas under standard conditions is 22 700 cm^3 (22.7 dm^3 mol^{-1}).

$$n(O_2) = \frac{500}{22\,700}$$

Multiplying by Avogadro's constant gives:

$$\text{number of molecules } (O_2) = \frac{500}{22\,700} \times \left(6.02 \times 10^{23}\right)$$

$$= 1.33 \times 10^{22}$$

QUESTION 18 A

A is correct. Subtracting the atomic number from the mass number shows that ^{32}S has 16 neutrons (32 – 16 = 16). ^{31}P also has 16 neutrons (31 – 15 = 16).

B is incorrect. ^{23}Na has 12 neutrons.

C and **D** are incorrect. ^{28}Si and ^{27}Al both have 14 neutrons.

QUESTION 19 A

Energy is absorbed (positive ΔH) when a bond breaks and released (negative ΔH) when a bond forms. Exothermic reactions release energy (negative ΔH) as the energy of bond formation in the products is greater than the energy required to break the bonds in the reactants.

QUESTION 20 C

C is correct. Solid sulfur exists as non-polar molecules held together by weak dispersion forces.

A and **B** are incorrect. Diamond and graphite have covalent networks.

D is incorrect. Sodium chloride is ionic and does not contain molecules.

QUESTION 21 D

The speed, energy and collision frequency of the molecules all increase the rate of reaction, but the number of molecules that have the required activation energy determines how much the reaction rate increases by.

QUESTION 22 D

D is correct. Water (H_2O) is a polar molecule because the electrons of the hydrogen atoms get 'pulled' towards the electrons of the oxygen atom. This makes a region of positive charge on the hydrogen atoms and a region of negative charge on the other end of the molecule, which is the oxygen atom. This also allows for hydrogen bonding.

A and **B** are incorrect. These options are true statements but they do not explain why water is polar.

C is incorrect. The different electronegativities of oxygen and hydrogen atoms result in polar bonds, but asymmetry is required for the molecule to possess a dipole. There is no net dipole in symmetrical molecules.

QUESTION 23 D

The activation energy (E_a) is the energy difference between the energy of the reactants and the top of the barrier. The change in enthalpy (ΔH) is the difference between the energy of the reactants and the energy of the products. As ΔH is negative, this indicates that energy is released during the reaction, meaning that the energy of the reactants should be greater than the energy of the products.

QUESTION 24 C

C is correct and **D** is incorrect. Property X is melting point. In period 3, melting point increases from group 1 (P – sodium) to group 13 (R – aluminium) as metallic bonding becomes stronger. It increases sharply for the covalent networks in group 14 (S – silicon), before falling sharply for the simple molecular structures in group 15 (T – phosphorus) onwards.

A is incorrect. S is silicon, which is a non-conductor, so property X cannot be electrical conductivity.

B is incorrect. T (which is in group 15), not S, has the highest electronegativity.

QUESTION 25 C

$PV = nRT$

$P = 101$ kPa

$$n(H_2O) = \frac{1}{18.02} = 0.0555 \text{ mol}$$

$R = 8.31 \text{ J mol}^{-1} \text{ K}^{-1}$

$T = 596$ K

$$V = \frac{nRT}{P} = \frac{0.0555 \times 8.31 \times 596}{101} = 2.72 \text{ dm}^3$$

SECTION 2

QUESTION 26 (4 marks)

a) i) $1s^2 2s^2 2p^6 3s^2 3p^1$

[1 mark]
1 mark for writing the full electron configuration.

ii) $1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^6$

[1 mark]
1 mark for writing the full electron configuration.

iii) $1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^{10} 4p^6$

[1 mark]
1 mark for writing the full electron configuration.

b) Sr^{2+}

[1 mark]
1 mark for identifying the ion.

QUESTION 27 (5 marks)

	C	H	Cl	F
Percentage (%) by mass	17.80	1.50	52.60	28.10
Number of moles	$\frac{17.80}{12.01} = 1.48$	$\frac{1.50}{1.01} = 1.49$	$\frac{52.60}{35.45} = 1.48$	$\frac{28.10}{19.00} = 1.48$
Ratio	1	1	1	1

The empirical formula is CHClF (total mass 67.5).

The molecular mass is 135, which is 2×67.5.

Therefore, the molecular formula is $C_2H_2Cl_2F_2$.

[5 marks]
1 mark for calculating the number of moles of each element.
1 mark for determining the ratio for each element.
1 mark for determining the empirical formula.
1 mark for using the molecular mass to determine the molecular formula.
1 mark for determining the molecular formula.

QUESTION 28 (3 marks)

bond enthalpies of reactants (+):

H–H = 436 kJ mol^{-1}

F–F = 159 kJ mol^{-1}

total = 436 + 159 = 595 kJ mol^{-1}

bond enthalpy of product (–) = H–F × 2 = 567 × 2 = 1134 kJ mol^{-1}

energy change = 595 – 1134 = –539 kJ mol^{-1}

[3 marks]

1 mark for calculating the total energy required to break the bonds in the reactants.
1 mark for calculating the total energy required to form the bonds in the products.
1 mark for calculating the energy change of the reaction.

QUESTION 29 (3 marks)

a) Sodium hydroxide solution could be added to the unknown solution.

[1 mark]

1 mark for proposing the chemical test.

b) A blue precipitate would be observed.

[1 mark]

1 mark for describing what would be observed.

c) $Cu^{2+}(aq) + 2OH^{-}(aq) \rightarrow Cu(OH)_2(s)$

[1 mark]

1 mark for writing the ionic equation.
Note: States are not required to obtain full marks.

QUESTION 30 (7 marks)

a) Sodium chloride has strong electrostatic attractions between its oppositely charged ions; these attractions require a lot of energy to be broken.

[1 mark]

1 mark for stating the reason for the high melting point.

b) When sodium chloride is in a solid state, its ions are unable to move. When sodium chloride is melted, its ions can move and enable electrical conduction.

[2 marks]

1 mark for stating that ions do not move in solid state.
1 mark for explaining that ions move in liquid state, enabling conduction.

c) Attractions between polar water molecules and the ions in sodium chloride can break the bonds in sodium chloride's lattice structure. There are no attractions between non-polar octane molecules and the ions in sodium chloride.

[4 marks]

1 mark for stating that water is polar and octane is non-polar.
1 mark for stating that there are attractions between water molecules and sodium chloride ions.
1 mark for stating that the attractions break the bonds in the lattice.
1 mark for stating that there are no attractions between octane molecules and sodium chloride.

QUESTION 31 (5 marks)

a) *Any two of:*

- Argon atoms are in constant random motion.
- Argon atoms have no attractions to each other.
- Argon atoms have negligible volume compared to total gas volume.
- The kinetic energy of argon atoms is proportional to temperature.

[2 marks]
1 mark for each correct assumption.

b) 6.02×10^{23} atoms

[1 mark]
1 mark for stating the number of atoms.
Note: The solution is Avogadro's constant as stated in the Formula and Data Booklet.

c) Argon is inert, so the tungsten filament does not burn. Air contains oxygen, which would cause the metal filament to burn.

[2 marks]
1 mark for stating that argon is inert.
1 mark for stating that oxygen causes metal to burn.

QUESTION 32 (3 marks)

a) Solubility at 90°C is 54 g per 100 g water. Solubility at 20°C is 8 g per 100 g water.
mass of pure solid = difference = 54 – 8 = 46 g

[2 marks]
1 mark for finding the solubilities at 90°C and 20°C.
1 mark for calculating the mass.

b) The graph shows solubility per 100 g of solution. If more solvent (hot water) was used, then more solute could dissolve and the mass of solid that would crystallise would be greater than 46 g.

[1 mark]
1 mark for predicting an increase in mass.

QUESTION 33 (5 marks)

a) Barium has a larger molar mass than calcium, so there are fewer moles in 5 g of barium than there are in 5 g of calcium, resulting in fewer moles of gas being produced.

[1 mark]
1 mark for stating the reason why the barium reaction produced a lower volume of gas.

b) The reaction using barium would have been faster than the reaction using calcium as barium is more reactive. This is because barium atoms are larger than calcium atoms and lose electrons more easily.

[2 marks]
1 mark for identifying a faster reaction rate.
1 mark for explaining why there is a difference in reaction rate.

c) The student could add a solution of sulfate ions (any soluble sulfate) to both flasks. Barium ions will produce a white precipitate of barium sulfate. Calcium ions will also produce a precipitate (calcium sulfate), but less precipitate will be produced as calcium sulfate is partially soluble.

[2 marks]
1 mark for proposing the test.
1 mark for predicting the results of the test.

