Neap

Trial Examination 2022

VCE Chemistry Units 1&2

Written Examination

Suggested Solutions

SECTION A – MULTIPLE-CHOICE QUESTIONS

Question	Answer	Question	Answer	Question	Answer
1	C	11	B	21	A
2	D	12	D	22	B
3	A	13	B	23	D
4	C	14	A	24	A
5	A	15	D	25	C
6	A	16	D	26	D
7	D	17	A	27	A
8	C	18	B	28	C
9	B	19	C	29	D
10	B	20	B	30	C

Question 1 C

C is correct. Electrons moving in defined orbits was proposed by Bohr and was modified considerably in Schrödinger's quantum mechanical model. This statement as written is not part of the model proposed by Schrödinger.

A, **B** and **D** are incorrect. These options are features of Schrödinger's quantum mechanical model.

Question 2 D

D is correct. In the structures of graphene (I), graphite (III) and fullerenes (IV), there are only three other carbon atoms bonded to each carbon atom. Thus, one electron in the outer shell of each carbon atom is not confined by a covalent bond. These delocalised electrons can move through the structures and conduct electricity.

A, **B** and **C** are incorrect. Diamond (II) is a three-dimensional covalent network lattice in which each carbon atom is bonded to four other carbon atoms. There are no delocalised electrons that would allow electrical conduction.

Question 3 A

A is correct. Delocalised electrons carry charge and can move through the various elemental carbon structures.

B and **C** are incorrect. There are no ions present in elemental carbon structures.

D is incorrect. Electrical conduction generally only occurs in solids by electron movement or in liquids by ion movement. Other charged particles are not involved in electrical conduction.

Question 4 C

C is correct. Alkenes have a C=C double bond that allows addition polymerisation to occur.

A, **B** and **D** are incorrect. These groups of compounds do not have the C=C double bond structure, which is a requisite for addition polymerisation.

Question 5 A

A is correct. The outer shell of $3s^2 3p^4$ gains two electrons to produce an ion with a double-negative charge and results in the electron configuration shown in option **A**. An almost-filled or just-filled third shell indicates that the element is non-metallic and is in period 3.

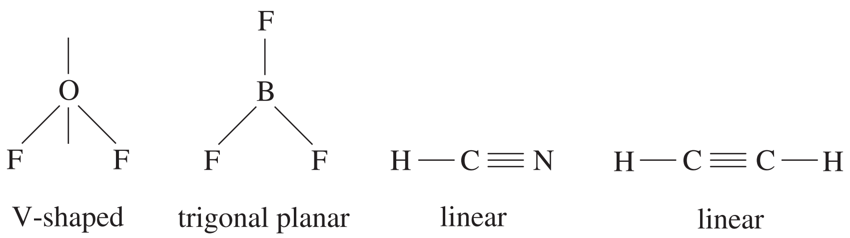
B is incorrect. This option is the transition metal chromium.

C is incorrect. Gain of electrons to form an ion usually involves the completion of the outer shell. The third shell in this option is still incomplete. In addition, if this was the configuration of a double-negatively charged ion, the parent atom would be magnesium, a metallic element.

D is incorrect. This option is the transition metal zinc.

Question 6 A

A is correct. OF_2 is V-shaped. The structures of each molecule are shown below.



B, **C** and **D** are incorrect. These options do not give the correct shapes of the molecules.

Question 7 D

$n(O) = 9 \times n(CuSO_4.5H_2O) = 9 \times 2.0 = 18$ mol

N(O atoms) $= n \times N_A = 18 \times 6.02 \times 10^{23} = 1.1 \times 10^{25}$ atoms

Question 8 C

C is correct. Cross-linking uses covalent bonds, which require a large amount of heat to disrupt. Therefore, high temperatures can be tolerated without change to the structure of a polymer.

A is incorrect. All polymers will burn at high temperatures.

B is incorrect. As thermosetting polymers have cross-linking with covalent bonds, it is difficult to recycle them, unlike thermoplastics, which will melt at low temperatures.

D is incorrect. Thermoplastics have dispersion forces between the chains, whereas thermosetting polymers have covalent bonds between the chains.

Question 9 B

B is correct. Statement I is correct as evidence is presented in the graph that the density of ice is lower than the density of liquid water, so ice will float on water. Statement III is correct as the density of water at 95°C is lower than the density of water at 25°C, so the warmer water will float on the colder water.

A, **C** and **D** are incorrect. Statement II is incorrect as heating ice to 0°C results in a sudden increase in density, which then decreases with further heating. This is not typical of the outcomes of heating other solids.

Question 10 B

B is correct. The water molecules in ice are held apart in an open structure by hydrogen bonding, so the density of ice is lower than the density of liquid water.

A, **C** and **D** are incorrect. These bonding types are not responsible for the open structure of ice.

Question 11 B

B is correct. The more electronegative atom will develop a small negative charge. As the molecule can be depicted as a dipole with distinct positive and negative ends, nitrogen is the negative end of the molecule.

A is incorrect. Ammonia is a highly polar molecule because there is a large difference between the electronegativity values of the atoms in the molecule and the molecule can be depicted as a dipole.

C is incorrect. The arrangement of the electron pairs is tetrahedral, but the bonding pairs give the shape of the molecule and are arranged in a pyramidal shape.

D is incorrect. The molecule has three bonding electron pairs and one non-bonding electron pair.

Question 12 D

D is correct. Oxygen is more electronegative than carbon, so it develops a small negative charge while carbon develops a small positive charge. Even though the covalent bonds in a carbon dioxide (CO_2) molecule are polar, the molecule has no overall polarity because it cannot be represented as a dipole since it has no distinct positive and negative ends.

A and **B** are incorrect. Both molecules are non-polar.

C is incorrect. Many linear molecules are polar, such as hydrogen fluoride (HF) and hydrogen choride (HCl).

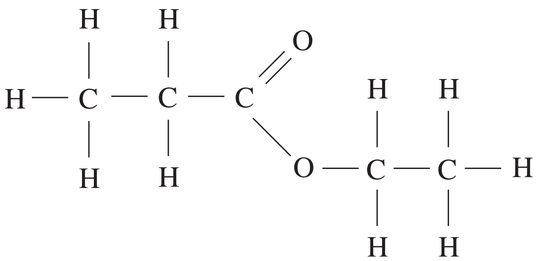
Question 13 B

B is correct. More reactive metals require greater application of energy or chemical means to isolate them from their ores than less reactive metals. Metal Q requires no intervention, so it is the least reactive metal. Metal Z requires the application of heat only, whereas metal X requires chemical reaction with carbon or its derivatives as well as strong heat. Metal Z is, therefore, less reactive than metal X. Metal Y is the most reactive metal as it can only be isolated from its ore by melting and using electrical means.

A, **C** and **D** are incorrect. These options do not give the correct order of increasing reactivity of the metals.

Question 14 A

A is correct. In naming an ester, the alcohol component is named first with the 'yl' ending. The acid part is named second with the 'oate' ending. The named ester therefore has a 2-carbon alcohol chain (ethyl) and a 3-carbon acid chain (propan). The correct structure of the ester is shown below.



B and **C** are incorrect. These options show the wrong carbon chains.

D is incorrect. This option does not show the required two oxygen atoms.

Question 15 D

D is correct. Most transition elements are hard and have high melting points, whereas the main group metals typically have much lower melting points and varying degrees of softness.

A is incorrect. Transition metals have properties directly opposite to these properties.

B is incorrect. Nickel, iron and cobalt are magnetic and so this property is not typical of most transition metals.

C is incorrect. All metals are ductile (able to be drawn into wires) to some extent.

Question 16 D

D is correct. HPO_4^{2-} can donate a proton to produce PO_4^{3-} or it can accept a proton to form $H_2PO_4^-$; therefore, HPO_4^{2-} is amphiprotic. It is also monoprotic because it can only donate one proton.

A, **B** and **C** are incorrect. These options do not correctly describe HPO_4^{2-}.

Question 17 A

A is correct. Iron ions are reduced ($Fe^{3+} + 3e^- \rightarrow Fe$) and act as the oxidant in the reaction.

B is incorrect. The oxidation reaction is $O^{2-} + CO \rightarrow CO_2 + 2e^-$. CO is oxidised and so is the reductant in the reaction.

C is incorrect. The oxidation number of carbon increases from +2 in CO to +4 in CO_2. This increase in oxidation number represents oxidation of carbon, not reduction.

D is incorrect. The oxidation number of oxygen throughout the reaction is –2, so no oxidation of oxygen atoms occurs.

Question 18 B

B is correct. Organic acids, such as citric acid, are weak acids. With a concentration of 0.100 M, the acid solution is dilute.

A, **C** and **D** are incorrect. These options do not correctly describe the concentration of the solution and the strength of citric acid.

Question 19 C

In the neutralisation reaction between nitric acid (HNO_3) and sodium hydroxide (NaOH), the mole ratio of NaOH : HNO_3 is 1 : 1.

$n(\text{NaOH}) = n(\text{HNO}_3) = cV = 1.00 \times 30.0 \times 10^{-3}$ mol

In the neutralisation reaction between citric acid and NaOH, the mole ratio of NaOH : citric acid is 3 : 1.

$$n(\text{citric acid}) = \frac{1}{3} \times n(\text{NaOH}) = \frac{1}{3} \times 1.00 \times 30.0 \times 10^{-3} = 10.0 \times 10^{-3} \text{ mol}$$

$$V(\text{citric acid}) = \frac{n}{c} = \frac{10.0 \times 10^{-3}}{0.100} = 0.100 \text{ L} = 100 \text{ mL}$$

Question 20 B

As $c_1V_1 = c_2V_2$, $0.100 \times 0.150 = 0.0650 \times V_2$.

$V_2 = 0.2308$ L = 230.8 mL

volume of water that must be added = 230.8 – 150 = 81 mL

Question 21 A

A is correct. The specific heat capacity of water is high, not low. This is due to the relatively strong intermolecular bonding between water molecules, which must be disrupted to raise the kinetic energy of the molecules and so raise the temperature.

B, **C** and **D** are incorrect. These options are all properties of water.

Question 22 B

$n(\text{sodium carbonate, Na}_2\text{CO}_3) = cV = 0.156 \times 0.2500 = 0.0390$ mol

$m(\text{Na}_2\text{CO}_3) = n \times M = 0.0390 \times 106.0 = 4.13$ g

Question 23 D

D is correct. By definition, the end point is the point at which the indicator shows a permanent colour change.

A is incorrect. If the acid and base are of different concentrations, the volumes reacting will not be equal.

B is incorrect. This option describes the equivalence point.

C is incorrect. The pH in the reaction flask may be 7 for a strong acid with strong base titration but will be above or below 7 if weak acids or bases are involved in the titration. Weak acids and bases produce weak bases and acids, respectively, at the equivalence point, and so the pH may not be 7.

Question 24 A

A is correct. It is proper scientific procedure to take more than one sample so that an average result can be calculated. The average is more reliable than a single piece of data.

B is incorrect. The samples are not pooled, and the 20.00 mL samples are more than sufficient to conduct tests without the suggested pooling.

C is incorrect. This option could be a valid reason if basic competence was an issue, but it is not the main reason for taking multiple samples.

D is incorrect. Only one wavelength is selected to analyse the samples. The samples are not consumed in the process of reading absorbance, so even if readings were to be made at different wavelengths, extra samples would not be required for this purpose.

Question 25 C

C is correct. The wavelength is selected so that the permanganate ion, MnO_4^-, absorbs strongly, and other components of the mixture absorb minimally. This increases the accuracy of concentration determinations.

A is incorrect. MnO_4^- absorbs strongly at this wavelength.

B is incorrect. Water is unlikely to absorb much radiation at any wavelength, and the purpose of selecting a particular wavelength is to maximise absorption of the substance under analysis.

D is incorrect. One wavelength cannot be effective at absorbing all colours.

Question 26 D

From calibration curve, an absorbance of 0.35 corresponds to a concentration of 55 mg L^{-1}. As the original sample was diluted by a factor of 12.5 $\left(\frac{250.0}{20.00} = 12.5\right)$, then the undiluted concentration = 55 × 12.5 = 687.5 mg L^{-1} = 6.9×10^2 mg L^{-1}.

Question 27 A

A is correct. Carbon dioxide gas reacts with water to form carbonic acid according to the equation $CO_2(g) + H_2O(l) \rightarrow H_2CO_3(aq)$.

B and **C** are incorrect. Neither nitrogen nor oxygen react with water.

D is incorrect. Nitrogen dioxide is not present in the atmosphere to any appreciable extent except when air pollution is present.

Question 28 C

C is correct. This option gives the correct concentration. 0.250 mg in 200 mL is equivalent to 0.125 mg per 100 mL or 1.25 mg per 1000 mL or 1.25 ppm.

A is incorrect. 0.250 mg per 200 mL = 1.25 mg per 1000 mL or 1.25×10^{-3} g L^{-1}.

B is incorrect. 0.250 mg per 200 mL = 0.125 mg per 100 mL = 1.25×10^{-4} g per 100 mL or 1.25×10^{-4} %(m/v).

D is incorrect. 0.250 mg per 200 mL = 1.25×10^{-3} g L^{-1} $= \frac{1.25 \times 10^{-3}}{19.0}$ $= 6.58 \times 10^{-5}$ mol L^{-1}.

Question 29 D

D is correct. The equivalence point is at pH 7. The initial pH of 1 increases slowly as more base is added. The final pH is greater than 12.5 and there is a sharp endpoint. These factors are indicative of a strong acid being titrated with a strong base.

A is incorrect. For a weak acid and a weak base titration, much more gradual pH changes would be expected and the initial pH and final pH would be closer to either side of 7.

B is incorrect. A weak acid would have a higher initial pH, and the pH at equivalence would be greater than 7 due to the presence of the conjugate weak base.

C is incorrect. A weak base would have a lower final pH, and the pH at equivalence would be less than 7 due to the presence of the conjugate weak acid.

Question 30 C

C is correct. The reaction is represented by the equation $Zn(s) + Ni^{2+}(aq) \rightarrow Zn^{2+}(aq) + Ni(s)$. The Zn strip would dissolve, decreasing in mass.

A is incorrect. The Ni^{2+} is reacting and so the green color would become lighter.

B is incorrect. Zn is a sufficiently strong reductant to reduce Ni^{2+}.

D is incorrect. Zinc nitrate is a soluble salt.

SECTION B

Question 1 (10 marks)

a. **i.** Millions of years ago, marine animals and plants died and settled at the bottom of the ocean. 1 mark

Sediments covered these dead organisms over time and they broke down to simpler compounds. 1 mark

Deposits of liquid carbon compounds were trapped between layers of rock under great pressure. 1 mark

ii. $C_{16}H_{34} \rightarrow C_7H_{16} + 3C_2H_4 + C_3H_6$ 3 marks

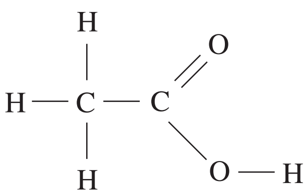
1 mark for using the correct formula of $C_{16}H_{34}$.
1 mark for using the correct formula of C_7H_{16}.
1 mark for using the correct formula of C_3H_6.
Note: Deduct 1 mark if $3C_2H_4$ is not shown.

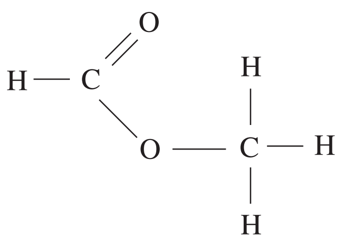
b. The hydrocarbon component of carboxylic acids is non-polar, so dispersion forces are the intermolecular bonds. 1 mark

As the number of atoms in the hydrocarbon component increases, so does the intensity of the dispersion forces. These stronger forces require a higher temperature for their disruption to allow boiling to occur. 1 mark

c. **i.** 1,1,2-trichloroethane 1 mark

ii. *For example, any one of:*





1 mark

Question 2 (10 marks)

a. **i.** Mg 1 mark

ii. Ar 1 mark

b. $1s^2 2s^2 2p^6$ 1 mark

c. **i.** Argon is a noble gas with eight outer-shell electrons. 1 mark

As reactions usually occur so that the reactants obtain an octet of outer-shell electrons by transferring or sharing electrons, no reaction will occur with the unreactive gas argon. 1 mark

ii. $2Na(s) + Cl_2(g) \rightarrow 2NaCl(s)$ 2 marks

1 mark for using the correct formulas of reactants and products.
1 mark for balancing and using the correct state symbols.

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iii.

Result	Explanation
does not conduct electricity as a solid	**The compound is composed of cations and anions. Ions in the lattice are held so that they do not move apart, so electricity is not conducted.**
conducts electricity when dissolved in water	**Dissolving the ionic lattice allows the ions to move, so electricity is conducted.**

3 marks
1 mark for recognising the ionic structure.
1 mark for each explanation (two required).

Question 3 (7 marks)

a. Isotopes are atoms of an element that have the same number of protons but different numbers of neutrons. 1 mark

b. i.

	Lighter isotope	**Heavier isotope**
Abundance	19.9%	80.1%
Relative isotopic mass	y	$y + 0.996$

1 mark

$10.8 = 0.199y + 0.801(y + 0.996)$ 1 mark

$y = 10.0122 = 10.0$ 1 mark

ii. $^{11}_{5}B$ 1 mark

c.

	^{58}Fe	^{58}Ni	^{59}Co	$^{60}Ni^{2+}$	$^{63}Cu^{2+}$
Atomic entity that has the largest number of electrons	26	28 ✓	27	28 – 2 = 26	29 – 2 = 27
Atomic entity that has the largest number of neutrons	32	30	32	32	34 ✓

2 marks
1 mark for each correct answer.
Note: Responses are not required to include values or calculations to obtain full marks.

Question 4 (8 marks)

a. $m(Cl) = 2.397 - 1.785 = 0.612$ g 1 mark

$n(\text{Pb}) : n(\text{Cl}) = \frac{1.785}{207.2} : \frac{0.612}{35.5} = 0.0086 : 0.0172 = 1 : 1.99$ 1 mark

The empirical formula of lead chloride is $PbCl_2$. 1 mark

b. This method relies on all the lead from the lead chloride being removed so that its mass can be determined accurately. Having excess aluminium powder ensures that all the lead ions have been converted to lead atoms. 1 mark

c. If the unreacted aluminium was not removed, the mass of the lead would have been apparently higher as some aluminium would be present. 1 mark

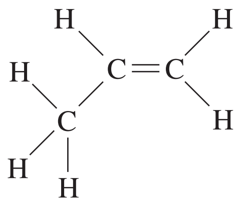
The mass of chlorine in the compound would have been calculated as being lower, so the calculated empirical formula of the compound would be incorrect. 1 mark

d. Lead chloride consists of a lattice of lead ions and chloride ions held to each other by ionic bonding. 1 mark

This strong bonding must be disrupted for the lattice to melt, and this will only occur when sufficient heat is provided for the ions to break away. 1 mark

Question 5 (10 marks)

a.



1 mark

b. M(propene) = 42 g mol^{-1}

290 000 = 42x 1 mark

x = 6905 monomers 1 mark

c. Bonding between the non-polar polymer chains is by dispersion forces only. 1 mark

These relatively weak forces are overcome as the polymer is heated, allowing it to soften and melt. 1 mark

d. *For example, any one of:*

- High-density polypropene (HDPP) will have a higher melting point than low-density polypropene (LDPP). 1 mark
  The more open structure of LDPP, due to the branching of the molecules, 1 mark
  weakens the dispersion forces between the chains leading to a lower melting temperature. 1 mark
- HDPP will be less transparent/more opaque than LDPP. 1 mark
  The more closely packed arrangement of the linear molecules in HDPP produces crystalline regions in the polymer, 1 mark
  which prevent the transmission of light, making it opaque. 1 mark

e. **i.** *For example:*

The recycling of polymers reduces the use of fossil fuels to make propene. 1 mark

ii. *For example:*

Polypropene, like other synthetic polymers, is non-biodegradable, so it may accumulate in landfill. 1 mark

Question 6 (11 marks)

a. Pd < Cr < La < Ba 1 mark

Note: The rule is that a more reactive metal will displace a less reactive metal from a solution of its ions, and so Pd must be the least reactive metal while Ba is the most reactive.

b. **i.** $2Cr(s) + 3Pd^{2+}(aq) \rightarrow 2Cr^{3+}(aq) + 3Pd(s)$ 2 marks

1 mark for correct reactants and products.
1 mark for correct balancing and state symbols.

ii. $Ba(s) \rightarrow Ba^{2+}(aq) + 2e^-$ 1 mark

c. **i.** Absorbance of 0.25 corresponds to 0.18 mg L^{-1}. 1 mark

As the waste liquid was diluted ×100, undiluted water has a Cr concentration of 18 mg L^{-1}. 1 mark

In 1.0 L, $n(\text{Cr}) = \frac{m}{M} = \frac{18 \times 10^{-3}}{52.0} = 3.46 \times 10^{-4}\ \text{mol L}^{-1} = 3.5 \times 10^{-4}\ \text{mol L}^{-1}$. 1 mark

ii. m(Cr) in 500 L of waste liquid = 18 × 500 = 9000 mg = 9.0 g 1 mark

iii. $n(\text{Cr}) = \frac{m}{M} = \frac{10.0}{52.0} = 0.1923\ \text{mol}$ 1 mark

$n(Cr(OH)_3) = n(Cr)$ 1 mark

$m(Cr(OH)_3) = n \times M = 0.1923 \times (52.0 + 51.0) = 19.8$ g 1 mark

Question 7 (8 marks)

a. **i.** hydrogen ion concentration = $10^{-pH} = 10^{-3.9} = 1.3 \times 10^{-4}$ M 1 mark

ii. pH = $-\log[H^+] = -\log(1.0 \times 10^{-3}) = 3$ (*strong acid completely ionised*) 1 mark

b. **i.** $Zn(s) + 2H^+(aq) \rightarrow Zn^{2+}(aq) + H_2(g)$ 2 marks

1 mark for correct reactants and products.
1 mark for correct balancing and state symbols.

ii. $2CH_3COOH(aq) + K_2CO_3(s) \rightarrow 2CH_3COOK(aq) + CO_2(g) + H_2O(l)$ 2 marks

1 mark for correct reactants and products.
1 mark for correct balancing and state symbols.

iii. $2HCl(aq) + MgO(s) \rightarrow MgCl_2(aq) + H_2O(l)$ 2 marks

1 mark the correct reactants and products.
1 mark for correct balancing and state symbols.

Question 8 (9 marks)

a. A contaminant is a substance that is present, which is not normally present or should not be present, in the solid, liquid or gas being considered. 1 mark

b. **i.** $n(\text{AgCl}) = \frac{m}{M} = \frac{0.0126}{143.4} = 8.7866 \times 10^{-5}\ \text{mol}$ 1 mark

n(NaCl) = n(AgCl)

$m(\text{NaCl}) = n \times M = 8.7866 \times 10^{-5} \times 58.5 = 5.1402 \times 10^{-3}$ g 1 mark

This mass is in 10.0 L, so $c(\text{NaCl}) = 5.14 \times 10^{-4}\ \text{g L}^{-1}$. 1 mark

ii. *For example, any one of:*

- It was assumed that chloride ions were the only ions present in the sample that reacted with silver ions and so the amount of silver chloride, AgCl, precipitate could be used to calculate the NaCl concentration.
- It was assumed that all chloride ions present in the sample precipitated.

1 mark

iii. *For example, any one of:*

- The electrical conductivity of a sample of the drain water could be compared with the conductivities of samples of known NaCl concentration.
- Atomic absorption spectroscopy (AAS) could be used to determine the sodium ion concentration in the sample.

1 mark

c. **i.** The retention time of ANTU is 5 minutes in the first HPLC output (Graph 1). 1 mark

As there is no peak at 5 minutes in the second HPLC output (Graph 2), it is reasonable to conclude that the drain water does not contain ANTU. 1 mark

ii. *For example:*

Each different compound interacts differently with the HPLC column and solvent. As there are five peaks in Graph 2, there are at least five different compounds present in the drain water sample. 1 mark

Question 9 (11 marks)

a. **i.** Ionic bonds in the potassium nitrate solid are broken. 1 mark

Hydrogen bonds between water molecules are broken. 1 mark

Ion–dipole attraction between the ions and the polar water molecules are formed. 1 mark

ii. Reading from the solubility curve, at 50°C, the solubility is 100 g in 100 g of water or 100 g in 100 mL of water (assuming a density of 1 g mL^{-1}). Therefore, there is 40 g of solute in 40 mL of saturated solution. 1 mark

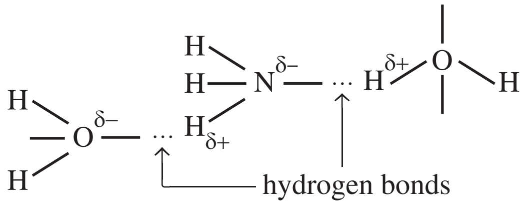
At 40°C, the solubility is 75 g in 100 mL of water, and so there is $\frac{75}{100} \times 40 = 30$ g per 40 mL of solution. 1 mark

Therefore, (40 – 30) = 10 g of potassium nitrate crystallises. 1 mark

b. There is some polarity at the hydroxyl end of the hexanol molecule, but the long hydrocarbon chain is non-polar. *(As the chain length increases, overall polarity decreases.)* 1 mark

Hydrogen bonding between water molecules will not be broken because most of the hexanol molecule is non-polar and so will not be held in solution by water molecules. 1 mark

c. Ammonia (NH_3) is a small molecule that has a nitrogen atom bonded to hydrogen atoms with highly polar covalent bonds. NH_3 molecules form intermolecular hydrogen bonds with water molecules, resulting in its high solubility. 1 mark



2 marks

1 mark for the correct molecular structures.

1 mark for correctly drawn and labelled hydrogen bonds.

Question 10 (6 marks)

a. $2H_2O(l) \rightleftharpoons H_3O^+(aq) + OH^-(aq)$ 2 marks

1 mark for the correct reactants and products.
1 mark for correct balancing and state symbols.

b. $[H_3O^+] = 10^{-pH} = 10^{-3.7}$

$K_w = [H_3O^+][OH^-] = 7.29 \times 10^{-14}$ 1 mark

$10^{-3.7} \times [OH^-] = 7.29 \times 10^{-14}$

$[OH^-] = 3.7 \times 10^{-10}$ M 1 mark

c. As the pure water is heated, the value of K_w increases, and so $[H_3O^+]$ increases because in pure water $[H_3O^+] = [OH^-]$ and $K_w = [H_3O^+]^2$. 1 mark

As $[H_3O^+]$ increases, the pH of the water decreases. 1 mark