Neap:

Trial Examination 2017

VCE Chemistry Unit 2

Written Examination

Suggested Solutions

SECTION A – MULTIPLE-CHOICE QUESTIONS

1	A	**B**	C	D		11	A	B	C	**D**
2	A	B	C	**D**		12	**A**	B	C	D
3	A	**B**	C	D		13	A	**B**	C	D
4	A	B	**C**	D		14	A	B	**C**	D
5	**A**	B	C	D		15	A	**B**	C	D
6	**A**	B	C	D		16	A	**B**	C	D
7	A	B	C	**D**		17	A	B	**C**	D
8	**A**	B	C	D		18	**A**	B	C	D
9	A	B	C	**D**		19	A	B	**C**	D
10	A	B	**C**	D		20	A	B	C	**D**

Question 1   B

The boiling points of the hydrides generally increase with molecular mass. However, as hydrogen bonding exists between water molecules, its boiling point is exceptionally high – in fact the highest of any of the hydrides shown. Thus, as H_2S is the smallest molecule of the remaining hydrides, it has the lowest boiling point.

Question 2   D

All of the hydrides are polar molecules and so dipole-dipole attraction is the common intermolecular bonding. **A** is not correct. The magnitude of the melting point depends on the strength of intermolecular bonding and so strength of the covalent bonds is not relevant. **B** is also incorrect. The pattern in melting points in these hydrides shows that **C** is incorrect. Water has a particularly strong form of dipole-dipole attraction (hydrogen bonding) between its molecules and so has the highest melting point of the hydrides in group 16. **D** is the required answer.

Question 3   B

Diprotic means that the acid is capable of donating two protons. Amphiprotic means that the chemical species is capable of donating a proton or accepting a proton. Only **B** has both of these properties.

Question 4   C

$[H_3O^+] = 10^{-3}$ M and so $n(H_3O^+) = 0.01 \times 10^{-3}$ mol in 10 mL.

After dilution, $[H_3O^+] = \dfrac{n}{V} = \dfrac{(0.01 \times 10^{-3})}{1.0} = 10^{-5}$ M and so pH = 5.

Note that dilution by a factor of 10 changes pH by one unit. Similarly, dilution by a factor of 100 changes pH by two units. Dilution will raise the pH of an acid, and lower the pH of a base.

Question 5   A

In reaction I, H_2O donates a proton to form OH^-, thus acting as an acid. The O^{2-} ion accepts the proton to form OH^-. In reaction II, the H_2O is reduced (gains electrons) to form OH^- and H_2, and thus acts as an oxidant. The Na is oxidised (loses electrons) to form Na^+.

Question 6   A

From the electrochemical series, the order of reactivity is Cu < Sn < Fe, so **C** and **D** are incorrect. A more reactive metal will displace a less reactive metal from its salt solution, so L is less reactive than Cu, Sn and Fe. M is more reactive than Cu, Sn and Fe. Q is more reactive than Cu, but less reactive than Sn and Fe. The required order is therefore L < Cu < Q < Sn < Fe < M.

Question 7   D

In a weak acid solution, ions are present and so **A** is incorrect. When HCOOH ionises, only the proton from the carboxyl functional group is lost, and so COO^{2-} ions are not formed as the other hydrogen is not ionisable. **B** and **C** are not correct. Weak acids ionise only partially in water and so the concentration of $HCOO^-$ ions is very low. **D** is correct and the required answer.

Question 8   **A**

As it is pure water, $[H_3O^+] = [OH^-] = 10^{-7}$ M at 25°C. However, at a different temperature, the value of the ionic product changes from $10^{-14} M^2$ and $[H_3O^+]$ will not be 10^{-7} M. Thus the pH of pure water is only 7 at 25°C. **A** is incorrect and is the required answer, whereas **B** and **D** are correct statements. At 25°C, the concentration of hydrogen ions is 10^{-7} M and the concentration of water molecules is close to 55.6 M. **C** is also a correct statement.

Question 9   **D**

Storing the samples for transport must include sterile conditions without contamination and preventing evaporation or spillage. **B** and **C** would be inadequate and are thus incorrect. The container must be sterile and sealed tightly. **A** could be used but there is no reason that single-use plastic containers must be used. Previously-used containers which have been cleaned and sterilised appropriately are quite acceptable and probably more beneficial environmentally. **D** is the required answer.

Question 10   **C**

To determine the chloride concentration by conductivity, standards of known concentration must be made and their conductivities established so that a calibration graph can be drawn. I, II and IV are correct. In gravimetric analysis, the chloride ion would be precipitated and its mass determined, but this technique is not relevant to electrical conductivity analysis. Action II is not required and so is incorrect.

Question 11   **D**

energy in water = $4.18 \times 75.0 \times (93.2 - 28.1) = 20\,408$ J

ΔT in copper = $\dfrac{20\,408}{0.390 \times 138.5} = 377.8°C$

Question 12   **A**

The latent heat values relate to the strength of interparticle forces which must be overcome to produce a change of state. **C** and **D** are correct statements. As the value for vaporisation is higher than for fusion for water, **B** is also a correct statement. The molar mass of a substance does not determine the latent heat values because the molar mass does not necessarily affect all interparticle forces. **A** is an incorrect statement and so is the required answer.

Question 13   **B**

Coolants are most effective when a large amount of heat energy can be absorbed without a change of state occurring. Substances with high latent heat values make very effective coolants.

Question 14   **C**

Flask 1 must have more hydrogen ions than flask 2 as the reaction with magnesium is much faster. It does not follow that Y is more dilute than X because Y could be a weak acid at the same concentration as X which could be a strong acid. **A** is incorrect. It also does not follow that X is stronger than Y because X could be a concentrated weak acid and Y could be a dilute strong acid. **B** is incorrect and **C** is correct. If the situation in **D** was accurate, flask 2 would have the faster reaction (a lower time taken than flask 1). Thus **D** is incorrect.

Question 15   B

The relevant equation is: $H_2A + 2NH_3 \rightarrow (NH_4)_2A$. The mole ratio is 1 mole of acid to 2 mole of ammonia, or 0.5 mole : 1.0 mole. The fact that ammonia is a weak base does not alter the amount of strong acid needed for its neutralisation.

Question 16   B

As the absorbance of 0.58 is outside the limits of the graph, either a new set of standards will need to be made so that a suitable calibration graph can be constructed (option II) or the test solution will need to be diluted so that its absorbance corresponds to a concentration of mercury (option III). It is not safe to simply extrapolate as the relationship may not be linear at higher concentrations (option I).

Question 17   C

If the solution is saturated; no more salt will dissolve. Adding more salt and/or shaking the mixture will not increase the amount of dissolved salt. Adding more water will dilute the solution, not increase its concentration. Increasing the temperature will increase the solubility of the salt and so allow some of the undissolved salt to enter the solution, thus increasing the concentration.

Question 18   A

Water in the pipette or burette will change the concentration of the solutions dispensed from them and so affect the number of mole dispensed. This will affect the calculated concentration of methanoic acid. Water in the flask is of no consequence as it is the reactant particles which are reacting together which is crucial while the volume in which they react is not relevant; that is, placing a solution into a wet flask will decrease its concentration but will not change the number of mole of solute.
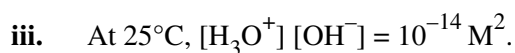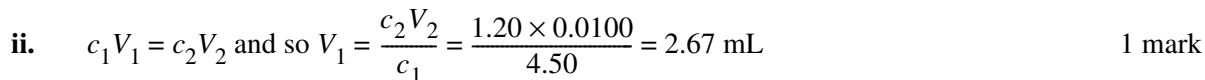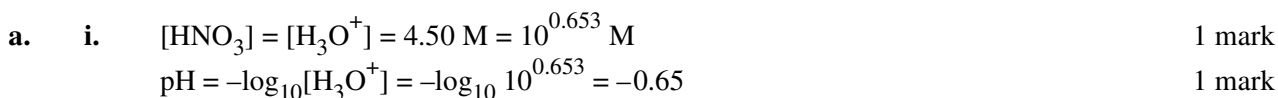
Question 19   C

There are three concordant titres. The average is $\dfrac{(18.95 + 18.90 + 18.90)}{3} = 18.917 \text{ mL}$. The correctly expressed answer, to four significant figures, is 18.92.

Question 20   D

A defines the equivalence point of the titration. At this point the added volumes may not be equal (for example the solutions may have different concentrations and will not mix in a 1 : 1 ratio by volume). The pH at the equivalence point depends on the nature of the chemicals present in the titration flask, and so is not always 7. Colour change defines the endpoint.
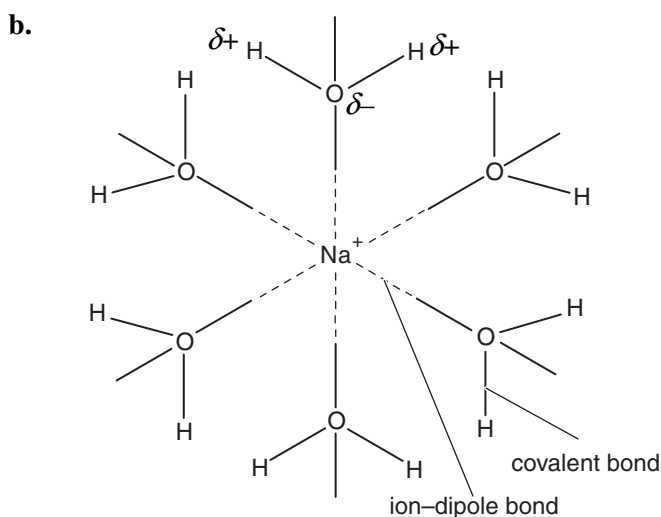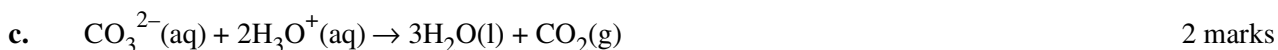
SECTION B

Question 1 (17 marks)

a.   **i.** $[HNO_3] = [H_3O^+] = 4.50$ M $= 10^{0.653}$ M   1 mark

            $pH = -\log_{10}[H_3O^+] = -\log_{10} 10^{0.653} = -0.65$ 1 mark

   ii. $c_1V_1 = c_2V_2$ and so $V_1 = \dfrac{c_2V_2}{c_1} = \dfrac{1.20 \times 0.0100}{4.50} = 2.67$ mL   1 mark

  iii.   At 25°C, $[H_3O^+]\,[OH^-] = 10^{-14}$ M^2.

            $[OH^-] = \dfrac{10^{-14}}{[H_3O^+]} = \dfrac{10^{-14}}{1.20}$ 1 mark

                  $= 8.33 \times 10^{-15}$ M   1 mark

b.

     2 marks

1 mark for correct naming of bonds.
1 mark for correct drawing and orientation.

c. $CO_3{}^{2-}(aq) + 2H_3O^+(aq) \rightarrow 3H_2O(l) + CO_2(g)$ 2 marks
     OR
     $CO_3{}^{2-}(aq) + 2H^+(aq) \rightarrow H_2O(l) + CO_2(g)$ 2 marks

1 mark for correct formulas.
1 mark for correct balancing and state symbols.

d.   **i.**   Washing removes any soluble ions (for example, excess Ba^{2+}) which are
            trapped on the precipitate.   1 mark

   ii.   Dry the filter paper and precipitate in an oven at 110°C. Allow to cool and
            weigh the precipitate and the filter paper.   1 mark

            Repeat the procedure until two consecutive masses are the same.   1 mark
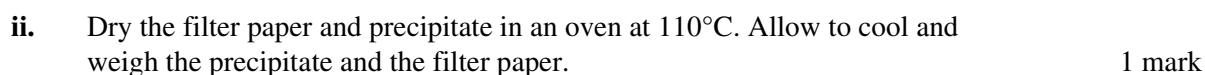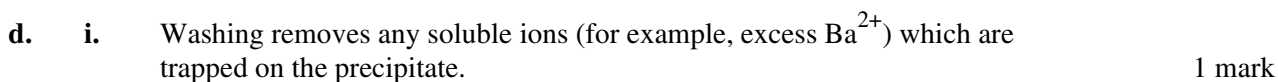
iii. $n(BaSO_4) = \dfrac{m}{M} = \dfrac{3.267}{233.4} = 0.013997$ mol   1 mark

$n(SO_4^{2-}) = n(BaSO_4)$

$m(SO_4^{2-}) = n \times M = 0.013997 \times 96.1$ g   1 mark

$c(SO_4^{2-})$ in % m/v $= m(SO_4^{2-}) \times \dfrac{100}{50.0} = 0.013997 \times 96.1 \times \dfrac{100}{50.0} = 2.69\%$ m/v   1 mark

e. Adding the silver ions to a mixture of sulfate ions and chloride ions would have precipitated both of the anions.   1 mark

The mass of the combined precipitate could not be used to determine the concentration of either ion.   1 mark

Question 2 (12 marks)

a.   **i.**   The solubility decreases as the temperature increases.   1 mark

     ii. N_2 : B; CO_2 : A; NH_3 : C   2 marks

1 mark for one correct match.
2 marks for three correct matches.

     iii.   dispersion forces   1 mark

     iv.   Oxygen gas dissolved in the water is needed by aquatic life to function normally. As less oxygen gas is dissolved in warmer water, the functioning of aquatic animals and plants will be impaired.   1 mark

b. Both molecules contain the polar hydroxyl group which can form hydrogen bonds with water molecules.   1 mark

Ethanol is a small molecule which forms hydrogen bonds with water molecules and is held in solution.   1 mark

1-hexanol has a long hydrocarbon chain which is non-polar and so water molecules will not be attracted to most of the molecule (even though some hydrogen bonds will form with the hydroxyl group).   1 mark

c.   **i.**   30 g in 55 g water is equivalent to $30 \times \dfrac{100}{55}$ in 100 g water; that is, 54.5 g (or 55 g) in 100 g water.   1 mark

        From the graph, this amount will dissolve at 25°C or above.   1 mark

     ii.   At 15°C, the solubility is 49 g per 100 gram water and so $\left(\dfrac{49}{100} \times 150\right) = 73.5$ g per 150 g of solution.   1 mark

        Therefore $150 - 73.5 = 76.5$ g will crystallise from solution when it is cooled to 15°C.   1 mark

Question 3 (12 marks)

a.   **i.**   Known standard solutions of each of the components are analysed in the HPLC column under identical conditions.   1 mark

        A component of a mixture can be identified if it has the same retention time as a standard compound.   1 mark

	ii.	Make standard solutions of acetone of different concentrations and determine the area under each peak using HPLC analysis.	1 mark
		Plot a calibration graph of area under peak versus concentration and use the area under the acetone peak in the mixture to read off its concentration on the graph.	1 mark
	iii.	$C_4H_{10}O + H_2O \rightarrow C_4H_8O_2 + 4H^+ + 4e^-$	1 mark
b.	**i.**	to compensate for any absorbance of light by the solvent and/or the cell	1 mark
	ii.	No light would be absorbed by the solution as purple light is not absorbed by a purple solution.	1 mark
	iii.	Absorbance of 0.35 corresponds to 55 mg L^{-1}.	1 mark
		As the waste water was diluted by a factor of $\frac{250.0}{20.0}$, then the original $c(MnO_4^-) = 55 \times \frac{250.0}{20.0} = 687.5 = 6.9 \times 10^2$ mg L^{-1}.	1 mark
	iv.	Change in concentration of $MnO_4^- = 78 - 20 = 58$ ppm = 58 mg L^{-1}	1 mark
		In 5000 L, mass of $MnO_4^- = 58 \times 5000 = 290\ 000$ mg = 290 g.	1 mark
		$n(MnO_4^-) = \frac{m}{M} = \frac{290}{118.9} = 2.4$ mol	1 mark

Question 4 (11 marks)

a.		$n(Cu(NO_3)_2) = c \times V = 0.50 \times 0.1000$ mol	1 mark
		$m(Cu(NO_3)_2) = n \times M = 0.50 \times 0.1000 \times 187.5 = 9.375 = 9.4$ g	1 mark
		Place 9.4 g of copper(II) nitrate in a 100 mL volumetric flask, add about 50 mL of water and shake to dissolve.	1 mark
		Add water to the mark and shake to produce a homogeneous solution.	1 mark
b.	**i.**	$Cu^{2+}(aq) + Pb(s) \rightarrow Pb^{2+}(aq) + Cu(s)$	1 mark
	ii.	$Cu^{2+}(aq)$	1 mark
	iii.	$Pb(s) \rightarrow Pb^{2+}(aq) + 2e^-$	1 mark
	iv.	$n(Cu)$ deposited $= \frac{m}{M} = \frac{2.362}{63.5} = 0.03719$ mol	1 mark
		final amount of copper $= [(0.50 \times 0.100) - 0.03719] = 0.0128$ mol	1 mark
		final concentration $= \frac{n}{V} = \frac{0.0128}{0.10} = 0.13$ M or 0.13 mol L^{-1}	1 mark
c.		There will be no change in the solution and no metal deposited on the copper.	1 mark

(From experiment 1, copper is a less reactive metal than lead. When solid copper is placed in a solution of lead ions, lead will not be deposited nor will any copper ions form.)