Neap:

Trial Examination 2016

VCE Chemistry Unit 2

Written Examination

Suggested Solutions

SECTION A – MULTIPLE-CHOICE QUESTIONS

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

Question 1 D

Statement I is not correct as most gases have very low solubility in water, unlike ammonia, which forms hydrogen bonds with water, and hydrogen chloride, a polar molecule which reacts with water. Statement II is incorrect as gas solubility decreases with increasing temperature, so the solubility of ammonia will be higher at 10°C than at 20°C.

Question 2 A

Over 95% of the Earth's water is in the oceans. Only a small percentage of water is found as fresh water.

Question 3 D

As sulfuric acid is a strong diprotic acid, the 0.01 M solution will produce hydrogen ions with the concentration greater than 10^{-2} M and so its pH will be less than 2. Carbonic acid is a weak diprotic acid and ionises to only a slight degree. Its hydrogen ion concentration will be much lower than 10^{-2} M and so its pH will be greater than 2.

Question 4 D

energy = $m \times c \times \Delta T = 1.5 \times 1000 \times 4.2 \times (100 - 17.5) = 519\ 750 = 5.2 \times 10^5$ J

Question 5 B

Statement I is incorrect as the specific heat capacity does not indicate the strength of bonding within a molecule. Statement II is correct as copper requires only 0.39 J of energy to increase a gram of the metal by 1°C, whereas all the other substances require a larger amount of energy. Water absorbs a large amount of energy comparatively before its temperature increases and so it is very effective as a coolant. Statement III is correct.

Question 6 B

The solution turns litmus red and so is acidic. Reaction II produces the hydronium ion and will produce an acidic solution.

Question 7 A

Metal X is least reactive as it does not displace any of the metal ions from their aqueous solutions. Metal Y is the most reactive as it displaces all of the metal ions. So **A** is the required answer.

Question 8 A

Silver metal forming when silver nitrate is tested with metals W, X, Y and Z indicates that silver is less reactive than each of the metals and so will not displace the metal ions from solution. **B** and **C** are not correct. Silver ions must be a stronger oxidant than the other metal ions as electrons are preferentially taken from each metal when in contact with silver ions. Thus silver metal must be the weakest reductant of any of the metals W, X, Y and Z. So **D** is incorrect. **A** is correct and the required response.

Question 9 B

The sample is weighed using an accurate balance, then transferred to a volumetric flask and the volume made up to the mark using deionised water. A pipette is not used, and so **B** is the required response.

Question 10 B

A conjugate pair is two related chemical species which differ from each other by a number of electrons: Mg/Mg^{2+} and H_2/H^+. Statement **A** is incorrect. In the reaction, magnesium has lost electrons and so has been oxidised by the hydrogen ions provided by the HCl solution. Statement **B** is correct. Oxidation involves a loss of electrons and so statement **C** is incorrect, as it shows magnesium gaining electrons. Chloride ions undergo no change in the reaction and so cannot be the reducing agents. Statement **D** is incorrect.

Question 11 C

$$c_1V_1 = c_2V_2$$

$$3.5 \times 35 = 1.2 \times V_2$$

$$V_2 = 102 \text{ mL}$$

So the amount of water added = 102 – 35 = 67 mL

Question 12 C

Latent heat of vaporisation relates to the heating of a liquid as it changes state. No increase in temperature occurs because the intermolecular bonding is being disrupted rather than the molecules gaining energy and moving faster.

Question 13 D

At point K, hydrogen bonds are being disrupted using the energy provided by heating and so no increase in temperature occurs as the state is changing. **A** is correct. As heating continues after the change from a solid to a liquid, the water molecules are gaining energy and moving faster at point L. **B** is also correct. Hydrogen bonding is further disrupted when the change of state from a liquid to a gas occurs and no temperature increase is evident even though heat is being added at point M. **C** is correct. When the water has vaporised at point N, intermolecular bonding is insignificant, but the water molecules are still intact, and so no covalent bonding has been broken. This would require much higher temperatures. **D** is incorrect and so is the required answer.

Question 14 C

$[Na^+] = 3 \times [Na_3PO_4] = 3 \times 0.0013 = 0.0039 \text{ mol L}^{-1}$

$m = n \times M$, hence $[Na^+] = 0.0039 \times 23 \text{ g L}^{-1} = 0.0897 \text{ g L}^{-1}$.

The volume of 150 mL has no significance in the calculation.

Question 15 B

These hydrides are V-shaped polar molecules which have higher boiling points than equivalent non-polar molecules because of the dipole-dipole attraction of the hydride molecules. These polar interactions are similar for all of the hydrides. **D** is not correct. The trend in the boiling points must be due to dispersion forces between the molecules, which are affected by the number of electrons which increases down the group. **B** is the correct answer. Intermolecular forces influence boiling points, not intramolecular forces such as covalent bonds. **A** is not correct. These hydrides are not capable of forming hydrogen bonds and so **C** is incorrect.

Question 16 C

The boiling point is influenced only by the bonding between the molecules, not within the molecules. **A** is not relevant to the explanation. Any dispersion forces between water molecules are insignificant compared to the hydrogen bonding, which has a major influence on its properties. As water is a small molecule, dispersion forces are extremely weak, and not strong as stated in **B**. As with the other hydrides, water molecules have dipole-dipole attraction. **D** is incorrect. As water consists of the small atoms H and O, any partial charge formed because of the polar nature of the bonds will be spread over a small volume leading to intense forces; that is, hydrogen bonding. **C** is the required answer.

Question 17 D

pH is a logarithmic scale, so dilution by a factor of 10 changes the pH by 1 unit. Diluting brick cleaner by a factor of 5 will change the pH by less than 1 unit. **A** is not correct. $[H^+]$ in milk is 10^{-6} M whereas $[H^+]$ in lemon juice is 10^{-3} M. **B** is incorrect. All aqueous solutions contain hydrogen ions, but in alkaline solutions, $[OH^-] > [H^+]$. **C** is also not correct. $[H_3O^+]$ in brick cleaner is 10^{-1} M and in oven cleaner is 10^{-13} M. At 25 °C, $[H_3O^+][OH^-] = 10^{-14}$ M^2, and so $[OH^-] = 10^{-1}$ M. **D** is correct and so is the required answer.

Question 18 C

The solubility of the solute must be 80 g per 100 g of water and this is possible down to 35°C. At a lower temperature, some solute will come out of solution.

Question 19 A

At 60 °C, 90 g of solute will dissolve in 100 g of water; that is, 67.5 g of solute in 75 g of water.

solute not dissolved = 75 – 67.5 = 7.5 g

Question 20 A

$c(\text{ethanol}) = \frac{7.65}{60.0} = 0.1275 \text{ g mL}^{-1} = 128 \text{ mg mL}^{-1}$

$0.1275 \text{ g mL}^{-1} = \frac{12.75 \text{ g}}{100 \text{ mL}}$; that is, 12.8% m/v.

$v(\text{ethanol}) = \frac{\text{mass}}{\text{density}} = \frac{7.65}{0.785} = 9.745$ mL, and so 9.745 mL in 60.0 mL = 16.2% v/v.

12.75 g in 100 mL is equivalent to 12.75×10^4 g in 10^6 mL; that is, 1.28×10^5 ppm.

A is incorrect and so is the required answer.

SECTION B – SHORT-ANSWER QUESTIONS

Question 1 (11 marks)

a. $H_2SO_4(aq) + ZnCO_3(s) \rightarrow ZnSO_4(aq) + H_2O(l) + CO_2(g)$ 2 marks

1 mark for reactants and products.
1 mark for balancing and states.

b. to remove any insoluble material contained in the mixture after the reaction with acid 1 mark

c. The zinc sulfate solution was heated to evaporate some of the water. 1 mark
(As water is evaporated, too much solute will be present for all of it to be held in solution, and some solid solute will form in the concentrated zinc sulfate solution.)

OR

The zinc sulfate solution was cooled to reduce the solubility of the zinc sulfate. 1 mark
(As the solution is cooled, too much solute will be present for all of it to be held in solution, and some solid solute will form in the concentrated zinc sulfate solution.)

d. At the temperature of the solution, no more solute can be dissolved in a given amount of solvent. 1 mark

e. Solubility of a solid increases with temperature and so using cold water to wash the crystals diminishes the possibility of dissolving some solid. 1 mark

A small amount of water was used because the solubility of the compound is very low, but not zero, and some compound may dissolve if large washing volumes were used. 1 mark

f. **i.** 10.0 mg L^{-1} 1 mark

ii. m(Zn) in 100 mL solution = 10.0 × 0.100 = 1.00 mg 1 mark

average mass of Zn ions per tablet = $\frac{1.00}{5}$ = 0.200 mg 1 mark

iii. to establish the numerical relationship between the measured quantity (absorbance) and the required quantity (concentration) 1 mark

Question 2 (17 marks)

a. *For example, any two of:*

- the sample collected must be representative of the body of water
- samples must be preserved to avoid deterioration during transport and storage
- containers and collection equipment must be cleaned to avoid contamination of the samples

2 marks

b. **i.** mass of dissolved solids = 42.67 – 42.19 = 0.48 g 1 mark

100.0 mL of solution = 100.0 g of solution

% dissolved solids = $\frac{0.48 \times 100}{100}$ = 0.48% 1 mark

ii. A range of water samples should be taken to determine the percentage of dissolved solid for each, then an average should be calculated. 1 mark

c. An absorbance of 0.331 gives a concentration of $\frac{0.331}{2.05}$ mg L^{-1} PO_4^{3-}. 1 mark

$\frac{0.331 \times 10^{-3}}{2.05 \times 95}$ mol L^{-1} = 1.70×10^{-6} M

The dam water does not comply to the limit of 1.04×10^{-6} M phosphate ion concentration. 1 mark

d. **i.** $Ag^{+}(aq) + Cl^{-}(aq) \rightarrow AgCl(s)$ 1 mark

ii. to ensure that all of the chloride ion is precipitated 1 mark

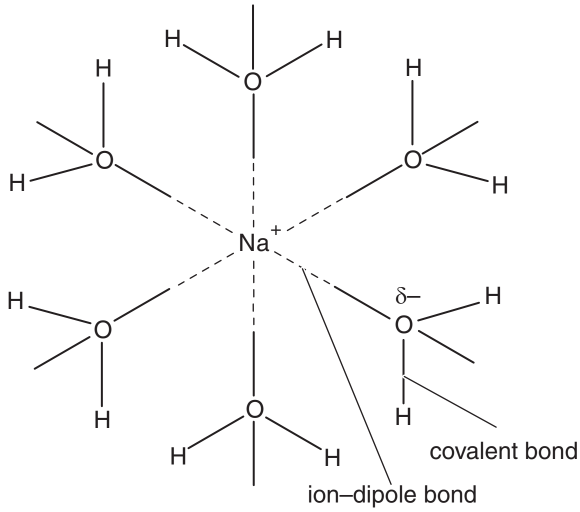
iii. $n(AgCl) = \frac{m}{M} = \frac{0.698}{143.4} = 0.004867$ mol 1 mark

$n(Cl^{-}) = n(AgCl)$

$m(Cl^{-}) = n \times M = 0.004867 \times 35.5 = 0.1727$ g 1 mark

0.1727 g in 100 mL = 1.727×10^{3} g in 10^{6} mL = 1.73×10^{3} ppm 1 mark

e.



1 mark

Water molecules colliding with sodium chloride crystals will break down the ionic lattice so that free sodium ions and chloride ions are in solution. 1 mark

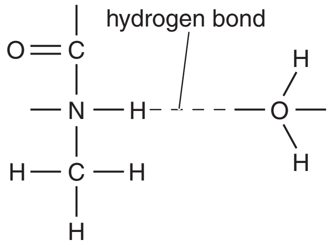
The positively charged sodium ions attract the partially negatively charged oxygen end of the polar water molecules by ion-dipole bonding. The negatively charged chloride ions attract the partially positively charged hydrogen end of the polar water molecules by ion-dipole bonding. 1 mark

f. Prepare a set of standard solutions of known concentration of sodium chloride and record the conductivity of these solutions. Plot a graph of conductivity versus concentration for the standards. 1 mark

Record the conductivity of the samples, read their concentrations from the graph and average the results. 1 mark

Question 3 (9 marks)

a.



2 marks

1 mark for correct orientation of water molecule.

1 mark for correct use of dashed line and label.

b. In the water sample, only aldicarb (8 mins) and carbaryl (16 mins) are present, as their retention times correspond to peaks on the first HPLC analysis. 1 mark

As the area under each peak is proportional to the amount of pesticide, aldicarb is approximately two to three times and carbaryl is approximately twice the concentration of these pesticides in the standards. 1 mark

c. $c(\text{aldicarb}) = 458 \times \frac{5.0}{3792}$

$= 0.603 \text{ mg L}^{-1}$ 1 mark

$= \frac{0.603 \times 10^{-3}}{190.1}$

$= 3.2 \times 10^{-6} \text{ M}$ 1 mark

d. **i.** $C_{12}H_4O_2Cl_4$ 1 mark

ii. *For example:*

Dioxins may be produced when wastes are burnt at insufficiently high temperatures in incinerators. These dioxins may find their way into streams. 1 mark

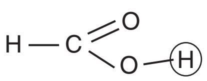
iii. *For example:*

Dioxins are non-polar molecules which are soluble in the non-polar fatty tissues of animals. 1 mark

Question 4 (10 marks)

a. **i.** an acid which does not fully ionise in water 1 mark

ii.



2 marks

1 mark for correct structure of methanoic acid.

1 mark for correct H atom circled.

b. **i.** The indicator is a substance which will change colour at a certain pH and so allow the equivalence point in a titration of colourless reactants to be identified. 1 mark

ii. $HCOOH(aq) + NaOH(aq) \rightarrow HCOONa(aq) + H_2O(l)$ — 2 marks

1 mark for reactants and products.
1 mark for balancing and states.

iii. $n(NaOH) = c \times V = 0.100 \times 19.75 \times 10^{-3}$ mol — 1 mark

$n(HCOOH) = n(NaOH) = 0.100 \times 19.75 \times 10^{-3}$ mol

$[HCOOH] = \frac{n}{V} = \frac{0.100 \times 19.75 \times 10^{-3}}{0.02000}$ M (in 20.00 mL aliquot) — 1 mark

Diluted by a factor of 10.0 to 250.0, hence:

$[HCOOH] = \frac{0.100 \times 19.75 \times 10^{-3}}{0.02000} \times \frac{250.0}{10.0} = 2.47$ M — 1 mark

iv. more than 7 *(due to the presence of the weak base $HCOO^-$ in the equivalence-point solution)* — 1 mark

Question 5 (8 marks)

a. i. Self-ionisation of water occurs according to the equation:
$2H_2O(l) \rightleftharpoons H_3O^+(aq) + OH^-(aq)$ — 1 mark

The electrical conductivity depends on the presence of these ions in the liquid water. — 1 mark

As pure water has 10^{-7} M H_3O^+ ions and 10^{-7} M OH^- ions, the concentration of ions is very low and so the conductivity is very low. — 1 mark

ii. At 15°C, $[H_3O^+] = [OH^-]$, so $[H_3O^+] \times [OH^-] = 4.51 \times 10^{-15} = [H_3O^+]^2$.

Therefore $[H_3O^+] = \sqrt{4.51 \times 10^{-15}} = 6.72 \times 10^{-8}$ M. — 1 mark

$pH = -\log_{10}[H_3O^+] = -\log_{10}(6.72 \times 10^{-8}) = 7.17$ — 1 mark

iii. $[H_3O^+] \times [OH^-] = 7.29 \times 10^{-14} = [OH^-]^2$
Therefore $[OH^-] = 2.70 \times 10^{-7}$ M. — 1 mark

b. i. oxidant *(Mg is the reductant)* — 1 mark

ii. $Cr_2O_7^{2-}(aq) + 14H^+(aq) + 6e^- \rightarrow 2Cr^{3+}(aq) + 7H_2O(l)$ — 1 mark