Neap

Trial Examination 2020

VCE Chemistry Unit 2

Written Examination

Suggested Solutions

SECTION A – MULTIPLE-CHOICE QUESTIONS

1	**A**	B	C	D
2	A	B	C	**D**
3	A	**B**	C	D
4	A	B	**C**	D
5	A	B	**C**	D
6	**A**	B	C	D
7	A	B	**C**	D
8	A	B	C	**D**
9	A	B	**C**	D
10	A	**B**	C	D

11	A	**B**	C	D
12	A	B	**C**	D
13	A	**B**	C	D
14	**A**	B	C	D
15	**A**	B	C	D
16	A	**B**	C	D
17	A	B	C	**D**
18	A	B	C	**D**
19	**A**	B	C	D
20	A	B	C	**D**

Question 1 A

Oxidising agents (oxidants) are electron acceptors. They allow other species to donate electrons and so be oxidised. When an oxidising agent accepts electrons, it is itself reduced.

Question 2 D

Spectator ions are present in reactions in solution, such as in precipitation reactions. They are components of the reactants, but appear unchanged on the products side of the chemical equation. **D** is the required answer. A redox reaction – for example, combustion of a fuel – does not necessarily take place in solution, and so spectator ions may not always be present. **A** is incorrect. Oxidising agents gain electrons in a redox reaction. **B** is incorrect. An acid loses a proton in an acid–base reaction. **C** is incorrect.

Question 3 B

Water is a polar compound with hydrogen bonding between the molecules, whereas cooking oil is essentially non-polar with intermolecular dispersion forces. Water has a high specific capacity, whereas the value for cooking oil would be much lower. Thus it takes more heat to raise the temperature of water by one degree than it does for the oil.

Question 4 C

The conversions in **A** and **D** could be achieved by dilution. Removal of water will achieve the conversion in **B**. A strong acid cannot be converted into a weak acid as the strength of an acid is a measure of its ability to ionise, and depends on the structure and bonding in the acid. The conversion in **C** is impossible to achieve.

Question 5 C

The changes of state will occur where heat is being added to the contents but the temperature is not changing – that is, sections 2 and 4. The added energy is used to change the arrangement of the particles in the substance. The latent heat of fusion of ice is shown by the plateau at 0°C and the latent heat of vaporisation is shown by the plateau at 100°C.

Question 6 A

The strongest intermolecular forces in water are hydrogen bonds but the much weaker dispersion forces are also present. Covalent bonds within the water molecules are not broken by heating between 0°C and 100°C, as they require much greater energy to disrupt them.

Question 7 C

$E = mc\Delta T$

For water: $E = 8.0 \times 4.18 \times (60 - 25) = 1170$ J

For lead: $1170 = 40 \times 0.13 \times \Delta T$

$\Delta T = 225°C$

Question 8 D

The component with the strongest attraction to the mobile phase moves through the column the fastest – that is, P – and so **A** and **B** are incorrect. The area under the peak is a measure of the concentration and so, even though the peak for P is about twice the height of the peak for S, the area of the peak for P is more than twice that of S. **C** is incorrect. The smallest area under any peak is for R and so **D** is the required answer.

Question 9 C

The only peak that is present at the same retention time in both outputs is at 4.0 minutes – that is, component S.

Question 10 B

As the components elute from the HPLC column, each absorbance is read at a selected wavelength to produce the trace in the output. Many different wavelengths are not used. The procedure in **B** is thus not required. The steps in **A**, **C** and **D** are routine and necessary to determine the concentration of a component.

Question 11 B

The reactants in a redox reaction are unlikely to be a conjugate redox pair, whereas a related reactant and product usually occur in a redox reaction. **A** is incorrect and **B** is correct. Related chemical species that differ by a proton is a conjugate acid–base pair. **C** is incorrect. A conjugate redox pair would rarely be present in an acid–base reaction. (The reaction $H^-(aq) + H_2O(l) \rightarrow OH^-(aq) + H_2(g)$ is a rare exception). **D** is incorrect.

Question 12 C

Reduction is the gain of electrons, so **A** and **D** are incorrect. **B** is not a correct, balanced half-equation as it shows a neutral atom gaining negative charge to become positively charged.

Question 13 B

From the balanced equation and molar masses:

46 g Na reacts with 71 g Cl_2

55 g Na will react with $\frac{55}{46} \times 71 = 85$ g Cl_2 (but only 80 g is available)

Na is in excess as there is insufficient Cl_2 for complete reaction. Some Na will remain after reaction is complete.

Question 14 A

Solution X: $[H_3O^+] = 10^{-3}$ M and $[OH^-] = 10^{-11}$ M

Solution Y: $[H_3O^+] = 10^{-6}$ M and $[OH^-] = 10^{-8}$ M

A is correct as the hydrogen ion concentration is 1000-times higher for X than Y. **B** and **C** are incorrect. The two solutions could be strong and weak acids, but solution Y could be the same acid as solution X – just more dilute. **D** is incorrect.

Question 15 A

The general rule is that a more-reactive metal will displace a less-reactive metal from a solution of its ions. **A** is the required answer. Metal M is less reactive than metal O and so no displacement will occur in O^{2+} solution. **B** is incorrect. Metal P will react with a solution of N^{2+} ions but the situation in **C** will not occur and so this is incorrect. The situation in **D** does not conform to the general rule as it involves two oxidising agents reacting, and so it is incorrect.

Question 16 B

At 35°C, $[H_3O^+] \times [OH^-] = 2.09 \times 10^{-14}\ M^2$.

In pure water, $[H_3O^+] = [OH^-]$ and so $[H_3O^+]^2 = 2.09 \times 10^{-14}\ M^2$.

Thus $[H_3O^+] = 1.45 \times 10^{-7}\ M = 10^{-6.83}\ M$ and so pH = 6.83.

Question 17 D

In pure water, $[H_3O^+] = [OH^-]$ irrespective of the temperature and it is always neutral. **D** is correct and **B** is incorrect. The value of the K_w increases with increasing temperature and so $[H_3O^+]$ also increases, but the pH decreases. **A** and **C** are incorrect.

Question 18 D

0.246 mol of ethanol = 0.246 × 46 = 11.3 g of ethanol and so **A** and **B** are equivalent.

11.3 g in 1000 mL is equal to 1.13 g in 100 mL; that is, 1.13% m/v, and so **C** is also equivalent.

11.3 g in 1000 mL is equal to 11.3×10^3 g in 10^6 mL; that is, 1.13×10^4 ppm. **D** is not equivalent, and so is the required response.

Question 19 A

The mole ratio of HCl : NH_3 is 1 : 1. Both solutions are 0.10 M, so equivalence will be reached after addition of 20.0 mL. The weak base will react completely with the strong acid in the 1 : 1 ratio. The flask initially contains ammonia, so the methyl red indicator will be yellow in the base solution, turning to red at the endpoint.

Question 20 D

In UV-visible spectroscopy, a wavelength of radiation that is absorbed strongly by the chemical under analysis is chosen. Where there are two substances present in one sample, a wavelength must be chosen that is absorbed strongly by the substance being investigated but has low absorbance by the other substance.

SECTION B

Question 1 (12 marks)

a. **i.** $HSO_4^-(aq) + H_2O(l) \rightleftharpoons SO_4^{2-}(aq) + H_3O^+(aq)$ 1 mark

(second ionisation is not complete; $\rightleftharpoons$ is used to show this)

ii. It is an acid that readily donates a proton to water.

OR

It is an acid that is completely ionised in water *(for the first proton only)*. 1 mark

b. $c_1V_1 = c_2V_2$

$18 \times V_1 = 1.5 \times 125$ 1 mark

$V_1 = 10.4 = 10$ L 1 mark

c. As HCl is a strong acid, all of the molecules ionise in the reaction with water and so:

$[H^+] = 1.0$ M $= 10^0$ M; that is, pH = 0. 1 mark

As sulfuric acid is also a strong acid but can donate two protons:

$[H^+] > 1.0$ M and so $[H^+] > 10^0$ M; that is, pH < 0. 1 mark

d. **i.**

Solution A	Gas B	Solid D
zinc sulfate	hydrogen	sodium carbonate **OR** sodium hydrogen carbonate

3 marks

1 mark for each correct answer.

ii. $H_2SO_4(aq) + CuO(s) \rightarrow CuSO_4(aq) + H_2O(l)$

OR

$H_2SO_4(aq) + Cu(OH)_2(s) \rightarrow CuSO_4(aq) + 2H_2O(l)$

2 marks

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

iii. redox 1 mark

Question 2 (8 marks)

a. $n = cV = 0.100 \times 0.050 = 5.0 \times 10^{-3}$ mol 1 mark

$m(K_2SO_4) = n \times M = 5.0 \times 10^{-3} \times 174.3 = 0.87$ g 1 mark

b. $Pb^{2+}(aq) + SO_4^{2-}(aq) \rightarrow PbSO_4(s)$ 1 mark

c. Some of the precipitate would stick to the sides of the beaker and so, by washing this solid off, all of the precipitate will be present on the filter paper. 1 mark

d. nitrate ions and potassium ions 1 mark

e. **i.** percentage yield = $\frac{1.38}{1.52} \times 100 = 90.8\ \%$ 1 mark

ii. Some precipitate was lost during filtration. 1 mark

Not all of the ions precipitated in step 2. 1 mark

Question 3 (11 marks)

a. **i.** The solubility decreases with increasing temperature, whereas for most solids solubility would increase with increasing temperature. 1 mark

ii. The solubility at 30°C is 52 g per 100 g of water – that is, 26 g per 50 g of water. 1 mark

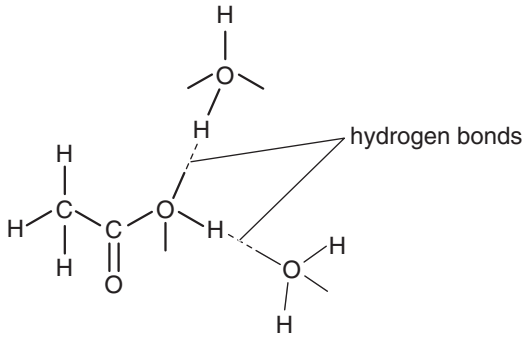
Place 26 g of sodium sulfate in 50 mL of pure water at 30°C and stir until no more solid will dissolve. 1 mark

iii. Add more solid and try to dissolve it at 30°C; if it is a saturated solution, no more solid will dissolve. 1 mark

b. Heated wastewater has less dissolved oxygen (as seen in the graph). 1 mark

Aquatic animals and plants take dissolved oxygen from the water to respire and produce the energy required for survival. Having less dissolved oxygen will affect the functioning of aquatic life and threaten the survival of many organisms. 1 mark

c. **i.**



2 marks

1 mark for correct drawing of the molecular interactions.
1 mark for correct orientation of water molecules and labelling.

Compound A is a small molecule that is capable of forming hydrogen bonds with water molecules and so it will be kept in solution. 1 mark

ii. Even though compound B has the same polar functional group as compound A, most of the large molecule is non-polar. 1 mark

Water molecules will not form significant intermolecular bonds with the large non-polar tail of the compound and so its solubility is very low. 1 mark

Question 4 (11 marks)

a. **i.**

Requirement for valid sampling	Procedure
Samples are representative of all the wastewater	Ensure that many samples are taken from different locations and depths within the storage.
Samples are kept securely and safely for transport and storage	Ensure that the samples are tightly sealed, fully labelled (including the date) and stored for transport so that no breakages or spillage could occur.

2 marks
1 mark for each correct answer.

ii. A chemical contaminant is a chemical species that is not normally present, or that is normally present in much lower concentrations, in a given location. 1 mark

b. **i.** The concentration of cadmium in the samples was too high for the calibration graph to be used. 1 mark

(*Dilution of the samples so that their absorbance relates to a cadmium concentration on the graph is the correct procedure, rather than extrapolation of the graph.*)

ii. absorbance of 0.45 $\rightarrow$ 5 ppm 1 mark

Accept responses between 4.5 and 5.5 ppm.

The concentration of the undiluted sample = $5 \times 5 = 25$ ppm. 1 mark

iii. 25 ppm = 25 mg per litre and so in 5000 litres there is 5000×25 mg = 125 000 mg. 1 mark

mass of cadmium = 0.13 kg 1 mark

c. **i.** *For example*:

AAS devices are expensive, but gravimetric analysis can be undertaken in any laboratory using basic apparatus and equipment. 1 mark

ii. *For example*:

Analysis by AAS produces results much faster than the labour-intensive gravimetric analysis method. 1 mark

AAS is inherently more accurate than gravimetric analysis as there is no possibility of most of the errors that can occur in gravimetric analysis (*for example, interference by other metals in the sample*). 1 mark

Question 5 (8 marks)

a. **i.** $n(\text{NaOH}) = cV = 0.127 \times 0.02235 = 0.002838 \text{ mol} = 2.84 \times 10^{-3} \text{ mol}$ 1 mark

ii. $n(\text{OH}^-) = n(\text{H}^+) = 0.002838 \text{ mol} = 2.84 \times 10^{-3} \text{ mol}$ 1 mark

iii. $c(\text{H}^+ \text{ ions}) = \frac{n}{V} = \frac{0.002838}{0.02000} = 0.142 \text{ M}$ 1 mark

iv. $\text{pH} = -\log_{10}[\text{H}^+] = -\log_{10}(0.142) = 0.85$ 1 mark

b. Animals and plants function properly within a narrow pH range. 1 mark

An environment outside this narrow range will impair proper functioning of living organisms, leading to disease and possibly death. 1 mark

c. NaOH absorbs water from the air, and NaOH reacts with carbon dioxide from the air. 1 mark

A pure sample of the solid cannot be obtained, and so a known accurate mass of NaOH cannot be determined. 1 mark

Question 6 (5 marks)

a. **i.** acid *(H_2O donates a proton and becomes OH^-)* 1 mark

ii. The HCl produced increases the hydrogen ion concentration and so lowers the pH. 1 mark

b. **i.** $H_2S(g) \rightarrow S(s) + 2H^+(aq) + 2e^-$ 1 mark

ii. $MnO_2(s) + 4H^+(aq) + 2e^- \rightarrow Mn^{2+}(aq) + 2H_2O(l)$ 1 mark

iii. *For example:* Fe^{2+} or H_2O 1 mark

