Neap:

Trial Examination 2013

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**

O_2 is an oxidant. H_2 is a reductant. H_3O^+ is an acid. OH^- is a base. **A** is therefore the correct response.

Question 2 **C**

The pressure (p) and number of mole (n) of gas remain constant, so $V_2 = V_1 \times \frac{T_2}{T_1}$

$T_1 = 313\ \text{K}$ and $T_2 = 293\ \text{K}$, so $V_2 = 10 \times \frac{293}{313} = 9.36\ \text{L}$

Question 3 **A**

Carbon dioxide is an acidic gas which produces an aqueous solution of pH less than 7. The other two gases will produce a neutral solution when bubbled into water. **A** is the correct response. Equal volumes of gases at the same temperature and pressure will contain equal numbers of mole, thus **B** will not distinguish the gases. Both carbon dioxide and nitrogen will extinguish a glowing splint, thus **C** will not distinguish carbon dioxide. The three gases are all colourless, thus **D** will not distinguish the gases.

Question 4 **D**

Distillation is an energy intensive and energy inefficient process which does not involve any chemical reactions in the evaporation and condensation of the water. So **A** and **B** are incorrect. Even though the concentration of ions increases as the water is evaporated from the saltwater, the total number of ions will remain constant and so **C** is also incorrect. Energy is used in evaporation of water, and will be released during its condensation. **D** is the required response.

Question 5 **C**

Experiment 1 shows that X and Y are more reactive than H_2, while Z is less reactive. Experiment 3 shows that Y is more reactive than X. Thus the order of increasing reactivity is Z < X <Y.

Question 6 B

Relevant equation is $Mg(s) + 2HCl(aq) \rightarrow H_2(g) + MgCl_2(aq)$.

Mg is in excess. 0.50 mol of HCl reacts with 0.25 mol of Mg, to form 0.25 mol of H_2 and 0.25 mol of $MgCl_2$. 0.25 mol of $MgCl_2$ contains 0.50 mol of Cl^- ions. Therefore **B** is the correct response.

Question 7 **A**

As the water is pure, it is neutral, which means that $[H_3O^+] = [OH^-]$. Statement I is accurate. As the pH is temperature-dependent, neutral solutions are only pH 7 at 25°C. Changing the temperature of this neutral solution will alter its pH. Statement II is also accurate. The water will be alkaline only if $[H_3O^+] < [OH^-]$. The $[H_3O^+] = 10^{-7}$ M at 25°C only. Changing the temperature of the water will alter $[H_3O^+]$. But it is pure water and must be neutral even though $[H_3O^+] < 10^{-7}$ M. Statement III is incorrect. Therefore **A** is the correct response.

Question 8 C

For the dilution $c_1V_1 = c_2V_2$

$$0.100 \times 50.0 = c_2 \times 150.0$$

$$c_2 = 0.0333 \text{ M}$$

As HA is a strong acid $[HA] = [H_3O^+]$

$pH = -\log_{10}[H_3O^+] = -\log_{10}(0.0333) = 1.47$ (closest to 1.5, hence **C** is the correct answer)

Question 9 D

Reduction involves a gain of electrons and so **A** and **C** are incorrect as there is a loss of electrons in these half-equations. Fe^{2+} is a product of the reaction whereas it is shown as a reactant in alternative B. Thus **B** is incorrect. **D** is the required response.

Question 10 B

Both statements I and III are factually correct but are not demonstrated by the experiment.

As the rusting of iron uses oxygen gas and 2 out of 10 units of gas volume have been consumed, statement II has been supported by the results of the experiment.

Question 11 D

$Ca(OH)_2$ dissociates in water and can be a source of hydroxide ions which will neutralise excess hydrogen ions in water. The aluminium ions produced from the dissociation of $Al_2(SO_4)_3$ form a jelly-like precipitate of $Al(OH)_3$ with hydroxide ions. This serves to trap fine suspended particles in flocculation. **A, B** and **C** are correct statements, and so are not the required responses. Chlorination is used to kill bacteria and other microbes. **D** is not a correct statement, and so is the required response.

Question 12 D

Covalent bonds hold the atoms in both ethanol and water within the molecule. Even though hydrogen bonding is the strongest intermolecular force between ethanol and water molecules, dispersion forces are still operating between atoms of the different compounds.

Question 13 B

Electrons flow towards the lead from electrode X. Therefore oxidation is occurring at X to generate electrons, and reduction is occurring at the lead electrode to accept electrons. $Pb^{2+}(aq) + 2e^- \rightarrow Pb(s)$. Reduction occurs at the cathode, hence **B** is the required response.

Question 14 D

The flow of electrons towards the lead half-cell indicates that Pb^{2+} is a stronger oxidant than X^{2+}, and X is a stronger reductant than Pb. From the electrochemical series, X therefore cannot be copper or silver, and must be either aluminium or nickel. Aluminium ions have a 3+ charge, and so **A** is not correct. **D** is the required response.

Question 15 A

Electrons flow from the X half-cell towards the Pb half-cell. Negative ions must therefore flow in the salt bridge from the Pb half-cell towards the X half-cell in order to balance the charges in each half-cell. The concentration of nitrate ions will therefore increase in the X half-cell. Thus **A** is the required response.

Question 16 C

The average kinetic energy of the particles is given by a value slightly greater than the peak of the distribution curve. T_2 has a greater value than T_1 and so statement I is incorrect. Increasing the temperature increases the speed of the particles, producing an increase in kinetic energy. Statement II is incorrect as there will be a higher proportion of particles with greater kinetic energy at higher temperatures. The average speed is directly related to the average kinetic energy and so statement III is correct. The nature of the distribution curve indicates that statement IV is correct. **C** is therefore the required response.

Question 17 A

$[H_3O^+] : [OH^-]$ for oven cleaner is $10^{-13} : 10^{-1}$, for lemon juice is $10^{-3} : 10^{-11}$, for tomatoes is $10^{-5} : 10^{-9}$ and for lime water is $10^{-11} : 10^{-3}$. Each pH unit is a change in $[H_3O^+]$ by a factor of 10. $[H_3O^+]$ in tomatoes is one-hundredth its concentration in lemon juice. **B**, **C** and **D** are correct statements. Diluting the lime water by a factor of 100 will produce a less alkaline solution, and so lower the pH by 2 units. Therefore the statement in **A** is incorrect, and so is the required response.

Question 18 B

Ice will be present in the beaker at *P* as it is being heated. At *Q*, both water and ice will be present but the temperature will not increase until all the ice has melted. No ice will be present after *Q*.

Question 19 B

The latent heat of fusion of ice can be seen at 0°C where heat is being added to the contents but no temperature change occurs (section *Q*). The latent heat of vaporisation occurs at 100°C where no change in temperature occurs until all the liquid water is vaporised (section *S*). Sections *Q* and *S* show latent heats, hence **B** is the required response.

Question 20 C

From equation $n(C_3H_8) : n(O_2) = 1 : 5 = 0.8 : 4$. So propane gas is in excess by $(3.0 - 0.8) = 2.2$ mol.
The products generated will be $0.8 \times 3 = 2.4$ mol of CO_2 and $0.8 \times 4 = 3.2$ mol of O_2.

Total number of mole of gaseous products after reaction $= 2.2 + 2.4 + 3.2 = 7.8$ mol.

As volume and temperature remain constant, $P_2 = n_2 \times \frac{P_1}{n_1} = 7.8 \times \frac{100}{7.0} = 111.4$ kPa.

SECTION B: SHORT-ANSWER QUESTIONS

Question 1 (13 marks)

a. **i.** Ionises only partially in water. 1 mark

ii. One hydrogen ion can be donated. 1 mark

b. $2CH_3COOH(aq) + CuCO_3(s) \rightarrow Cu(CH_3COO)_2(aq) + CO_2(g) + H_2O(l)$ 2 marks

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

c. The water in the filtrate could be removed by heating. 1 mark

d. **i.** $n(CH_3COOH) = c \times V = 0.50 \times 0.050 = 0.025$ mol 1 mark

ii. $n(Cu(CH_3COO)_2) = \frac{1}{2} \times n(CH_3COOH) = 0.0125$ mol 1 mark

$m(Cu(CH_3COO)_2) = n \times M = 0.0125 \times 181.5 = 2.3$ g 1 mark

e. *Any one of:*

- Not all of the copper(II) ethanoate was collected in the filtrate after filtration. Some may be trapped in the residue on the filter paper or present in the solution which wet the filter paper.
- Some ethanoic acid in the solution did not react due to inadequate stirring of the mixture.
- Some dry copper(II) ethanoate was not transferred from the beaker to the weighing dish.

1 mark

f. To ensure all of the ethanoic acid was used in the reaction, an excess of copper(II) carbonate was added i.e. some unreacted copper carbonate remained in the beaker. *If this was not done, the unreacted ethanoic acid would be present in the filtrate and the product of the preparation would not be pure.*

1 mark

g. **i.** The rate of the reaction to produce carbon dioxide would be increased.

OR

The mass of product would be decreased as $M(CuCl_2) < M(Cu(CH_3COO)_2)$. 1 mark

ii. *Statements 3 and 5 are correct* 2 marks

Question 2 (18 marks)

a. i. sodium chloride and potassium nitrate 1 mark

ii. At 10°C, the solubility is $\frac{21\text{ g}}{100\text{ g}}$ i.e. $\frac{6.3\text{ g}}{30\text{ g}}$ 1 mark

$\therefore 10 - 6.3 = 3.7$ g will crystallise 1 mark

iii. At 40°C, the solubility is 66 g in 100 g of water

$n(\text{KNO}_3) = \frac{m}{M} = \frac{66}{101.1}$ mol 1 mark

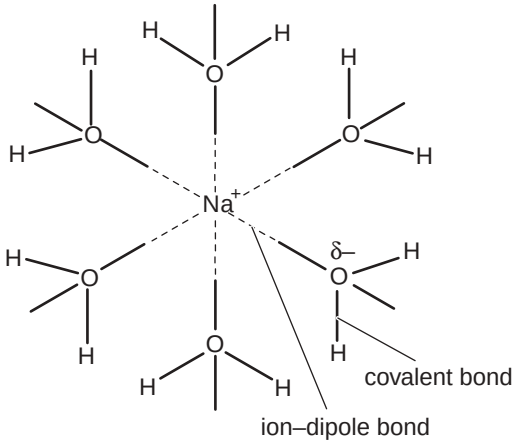
$N(\text{K}^+\text{ ions}) = n \times N_A = \frac{66}{101.1} \times 6.02 \times 10^{23} = 3.9 \times 10^{23}\ \text{K}^+$ ions 1 mark

b. i. $n(\text{NaCl}) = \frac{m}{M} = \frac{3.0}{58.5}$ mol 1 mark

$c(\text{NaCl}) = \frac{n}{V} = \frac{3.0}{58.5 \times 0.250} = 0.21$ M 1 mark

ii. 3.0 g in 250.0 mL $= 3.0 \times \frac{100.0}{250.0}$ g in 100.0 mL = 1.2% m/v 1 mark

c.



2 marks

d. i. The solid NaCl would dissolve faster in hot water. 1 mark

ii. Hot water requires energy to produce and thus adds to production costs;

or

The solubility of NaCl is almost constant from 0°C to 90°C and so hot water gives no advantage to solubility. 1 mark

iii. $\text{Mg}^{2+}(\text{aq}) + 2\text{OH}^-(\text{aq}) \rightarrow \text{Mg(OH)}_2(\text{s})$ 1 mark

e. i. Cl^- *(The reductant will undergo oxidation in the reaction and its oxidation number will increase. The O.N. of Cl in NaCl changes from –1 to 0).* 1 mark

ii. $2\text{Cl}^-(\text{aq}) \rightarrow \text{Cl}_2(\text{g}) + 2\text{e}^-$ 1 mark

iii. $n(\text{NaCl}) = \frac{m}{M} = \frac{10^6}{58.5} = 1.709 \times 10^4$ mol 1 mark

$n(\text{H}_2) = \frac{1}{2} \times n(\text{NaCl}) = 8.547 \times 10^3$ mol 1 mark

$V(\text{H}_2)$ at SLC $= n \times V_M = 8.547 \times 10^3 \times 24.5 = 2.09 \times 10^5$ L 1 mark

Question 3 (10 marks)

a. *Either:*

- Carbon dioxide:

  Glucose is fermented in the absence of oxygen using yeast. 1 mark

  In addition to the main product ethanol, the by-product carbon dioxide gas is also produced in the industrial process. 1 mark

  OR

- Oxygen or nitrogen:

  After removing particulates, water vapour and carbon dioxide from air, it is cooled to become a liquid. 1 mark

  In a fractionating tower, the liquid air is warmed so that nitrogen gas is removed followed by oxygen gas in the process of fractional distillation. 1 mark

b. i. amphiprotic 1 mark

ii. $HCO_3^-(aq) + H_2O(l) \rightarrow H_2CO_3(aq) + OH^-(aq)$ 1 mark

This reaction occurs, forming OH^- ions to produce a basic solution at 25°C. 1 mark

c. i. At low pressures, the molecules are large distances apart and so the attractive forces are negligible. 1 mark

At high temperatures, the molecules have high kinetic energy and thus any energy loss in collisions is negligible as a proportion of the total energy of the particles i.e. the collisions are elastic. 1 mark

ii. *For example, one of:*

- Extract the CO_2 used to make $scCO_2$ from a process which generates the gas e.g. burning fossil fuels.
- Capture the CO_2 gas released from the solution and recycle it as $scCO_2$ or use it as a reactant in photosynthesis by growing plants.

1 mark

iii. *Sample response for number 3 or 8:*

Extracting agents used previously have been toxic and must be disposed of in a safe manner to protect humans and the environment. Using $scCO_2$ allows safe extraction of caffeine with no possible residual contamination or danger to humans. 2 marks

Question 4 (14 marks)

a.

Chlorofluorocarbons	Oxides of nitrogen	Carbon monoxide	Sulfur dioxide
C	D	B	A

4 marks

b. **i.** $CH_4(g) + 2O_2(g) \rightarrow CO_2(g) + 2H_2O(g)$ 2 marks

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

ii. Methane is a more powerful agent causing enhanced greenhouse effect. Thus burning the methane removes this agent and, although less powerful agents water vapour and carbon dioxide gas are formed, the overall result reduces the enhanced greenhouse effect. 1 mark

iii. Heating will increase the rate of chemical reactions in the plant and assist plant growth. 1 mark

Burning methane produces carbon dioxide gas which is a reactant in photosynthesis and so this will also assist with plant growth. 1 mark

c. **i.** use of furnaces or using engines 1 mark

ii. $N_2(g) + O_2(g) \rightarrow 2NO(g)$ or $2NO(g) + O_2(g) \rightarrow 2NO_2(g)$ 1 mark

iii. nitrogen fixation 1 mark

iv. Denitrifying bacteria in the soil release nitrogen gas from compounds or ions 1 mark

v. *Any one of:*

- NO_3^-
- NH_3
- NH_4^+

1 mark

