

Trial Examination 2012

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 C

Statement I is correct, as the increase in temperature will increase the kinetic energy of the molecules and allow them to break free from the ice crystal. Statement III is also correct as the structure of the crystal is broken down and the water molecules are able to pack closer together. Statement II is incorrect as water molecules are held to each other in the liquid state by hydrogen bonding.

Question 2 C

Given the same amount of energy, the change in temperature of lead will be three times larger than the change in temperature of copper for equivalent masses of the metals. Thus **A** is not correct. The same reasoning applies to **B**, as the lower the value of the SHC, the higher the temperature will rise per unit of energy added. So **B** is incorrect. The temperature of iron will not rise above 100°C (the boiling temperature of water) irrespective of its SHC, so **D** is not correct. It takes almost nine times the amount of heat to achieve a set temperature for one gram of water as it does for one gram of sand, so **C** is correct and is the required answer.

Question 3 B

For pure water to be a poor conductor of electricity there must be few ions present. **B** is thus the correct answer. The conduction of electricity is not dependent on the intermolecular forces between water molecules or its latent heat of vaporisation. Thus **A** and **C** are factual statements, but are not correct explanations given the context of the question. Alternative **D** is wrong as electrons do not escape the covalent bond.

Question 4 D

The chemical species in each alternative which are not amphiprotic are: **A** – H_2SO_4 ; **B** – HCl , SO_4^{2-} and CH_3COO^- ; **C** – NH_4^+ , H_3O^+ and PO_4^{3-} . All substances in alternative **D** are capable of donating or accepting a proton.

Question 5 C

Only in pure water or neutral solution is $[\text{H}_3\text{O}^+] = [\text{OH}^-]$. Therefore statement I is incorrect. Statement II is accurate because boiling would remove dissolved carbon dioxide gas, and cooling to 25°C would produce water of about pH 7. Oxides of nitrogen dissolving in rainwater produce a greater acidity than pH 6 and so statement III is not correct. Carbon dioxide gas dissolving in rainwater produces H_2CO_3 , forming a mildly acidic solution. Therefore statement IV is correct.

Question 6 D

The graphs in **A** and **B** are straight lines going through the origin. The graph in **C** is a hyperbola.

Question 7 A

Nitrogen fixation involves converting atmospheric N_2 to compounds which may be absorbed by plants. Only alternative **A** satisfies this description.

Question 8 D

Given the mass of the precipitate, the molar ratio in the balanced chemical equation would allow the mass of sodium chloride to be determined. Thus **A** is correct. As an excess of silver nitrate solution was added initially, the addition of a greater excess would not produce more precipitate, as all the chloride ions were already in the precipitate. So alternative **C** is correct. The precipitate and the filter paper should be heated to constant mass so that it is certain that no water remains. **B** is correct. Substances which are dissolved in the water will pass through the filter paper during filtration. The filtrate will not be pure water. So **D** is incorrect and is the required answer.

Question 9 D

$$n(\text{Ba}(\text{OH})_2) = \frac{m}{M} = \frac{4.50}{171.3} \text{ mol}$$

$$n(\text{OH}^-) = 2 \times n(\text{Ba}(\text{OH})_2)$$

$$[\text{OH}^-] = \frac{n}{V} = 2 \times \frac{4.50}{171.3 \times 0.2500} = 0.210 \text{ M}$$

Question 10 B

The KMT assumes that the gas particles have very high energy and are a large distance apart. In this situation, energy losses in collisions, attractive forces between the particles, and the volume of the particles are all negligible. If the gas particles are slowed down and forced to be nearer to each other, then these quantities become significant. Thus statements I, II and III are not applicable at low temperatures and high pressures. The particles are still colliding, so statement IV remains valid.

Question 11 B

Lowering the temperature causes the curve to skew to the left and have a higher peak. The downward slope to the right of the peak becomes more severe. Only the values shown in alternative **B** match these requirements.

Question 12 D

$\text{O} + 2\text{e}^- \rightarrow \text{O}^{2-}$. Oxygen atoms gain two electrons to form oxide ions. This is a reduction process. The oxygen atom is accepting electrons and so is acting as an oxidant. Proton transfer does not occur in redox reactions.

Question 13 B

mole ratio $\text{Cr}_2\text{O}_7^{2-} : \text{I}^- = 1 : 6$

0.0090 mol of $\text{Cr}_2\text{O}_7^{2-}$ will react with $6 \times 0.0090 = 0.054$ mol of I^- , however, 0.058 mol are present, thus I^- is in excess.

$$n(\text{I}_2) = 3 \times n(\text{Cr}_2\text{O}_7^{2-}) = 3 \times 0.0090 = 0.027 \text{ mol}$$

Question 14 C

Collection of a prepared gas by the displacement of water is the most convenient method, as it provides certainty about the amount of gas formed. As gas Z has not been collected over water, it is likely that it is water soluble. A gas collected by the upward displacement of air must be denser than air.

Question 15 A

As the containers are both at the same temperature, the average kinetic energy of the particles must be the same. **A** is the correct answer. For constant V and T , $p \propto n$, $n(\text{NH}_3) = \frac{m}{M} = \frac{34}{17}$, $n(\text{PH}_3) = \frac{m}{M} = \frac{34}{34}$. The number of mole of gas in container A is twice that in container B. Hence, alternatives **B** and **D** are incorrect. The average kinetic energy of both gases is the same, and the gas particles of NH_3 are half the mass of PH_3 particles. The NH_3 particles must therefore be travelling at higher average speeds $\text{KE} = \frac{1}{2} \times m \times v^2$. Alternative **C** is incorrect.

Question 16 B

At around 28°C, the solubility of both solutes is 30 g per 100 g of water. As 50 g of water was used to make the saturated solutions, the mass of each solute used was 15 g. At 60°C, the solubility of ammonium chloride is 36 g per 100 g of water (or 18 g per 50 g) and for potassium nitrate is 84 g per 100 g (or 42 g per 50 g). The additional masses of each solute required to maintain saturation at 60°C are 3 g of ammonium chloride and 27 g of potassium nitrate.

Question 17 A

In **A**, a precipitate forms and there is no transfer of electrons. This is not a redox reaction. In **B**, **C** and **D**, the redox reactions all involve a transfer of electrons from a reductant (Pb, Mg and Ni) to an oxidant (H^+ , Cl_2 and Sn^{2+}).

Question 18 A

Halving the volume will double the pressure. Halving the absolute temperature will halve the pressure. Overall the pressure will remain the same.

Question 19 C

Gas molecules of any size or molecular mass would produce a gas pressure in the cylinder. Thus **A** and **D** are incorrect. Even without a tight seal, some gas would remain in the cylinder and its pressure would be detected. Alternative **B** is also incorrect. Changing the conditions so that the gas condenses to a liquid would produce zero gas pressure. **C** is the required answer.

Question 20 A

A reductant donates electrons and so is itself oxidised. Fe is the reductant. Oxidation (loss of electrons) occurs at the anode. Fe is reacting at the anode.

SECTION B: SHORT-ANSWER QUESTIONS

Question 1

- a. i. When hydrogen chloride dissolves in water, the molecules are ionised.
- $$\text{HCl(g)} + \text{H}_2\text{O(l)} \rightarrow \text{H}_3\text{O}^+(\text{aq}) + \text{Cl}^-(\text{aq}) \quad 1 \text{ mark}$$
- This ionisation reaction produces ions which conduct the current in the solution. 1 mark
- ii. When hydrogen chloride dissolves in methylbenzene, the molecules remain intact. Ionisation does not occur and so there are no hydrogen ions to produce the acidic properties observed for aqueous HCl. 1 mark
- iii. $2\text{HCl(aq)} + \text{Mg(s)} \rightarrow \text{MgCl}_2(\text{aq}) + \text{H}_2(\text{g})$ 2 marks
- 1 mark for correct reactants/products*
1 mark for correct states and balancing
- iv. $n(\text{Mg}) = \frac{m}{M} = \frac{0.576}{24.3} \text{ mol}$ 1 mark
- $$n(\text{H}_2) = n(\text{Mg}) \quad 1 \text{ mark}$$
- $$V(\text{H}_2) = \frac{nRT}{p} = \frac{0.576 \times 8.31 \times 291}{24.3 \times 101} = 0.568 \text{ L} \quad 1 \text{ mark}$$
- v. The solution formed should be heated to evaporate the water, leaving a solid salt. 1 mark
- b. i. As the acids are of the same concentration, Acid A must be a strong acid and Acid B is a weak acid. 1 mark
- Weak acids ionise only partially and thus will take longer to react with metals, and will conduct electricity to a lesser degree than strong acids. 1 mark
- ii. neutralisation 1 mark
- iii. Acid A must be diprotic. 1 mark
- Only half the volume of it was needed to provide the required number of hydrogen ions to neutralise the base of the same concentration.*
- $$\text{i.e. } n(\text{NaOH}) = c \times V = 2.0 \times \frac{10}{1000}$$
- $$n(\text{A}) = c \times V = 2.0 \times \frac{5}{1000} = \frac{1}{2} \times n(\text{NaOH})$$
- iv. $[\text{OH}^-] = 2.0 \text{ M}$ and at 25°C $[\text{H}_3\text{O}^+][\text{OH}^-] = 10^{-14} \text{ M}^2$.
- $$[\text{H}_3\text{O}^+] = \frac{10^{-14}}{2.0} = 5.0 \times 10^{-15} \quad 1 \text{ mark}$$
- $$\text{pH} = -\log[\text{H}_3\text{O}^+] = -\log(5.0 \times 10^{-15}) = 14.3 \quad 1 \text{ mark}$$

Question 2

- a. i. $2\text{Cl}^-(\text{aq}) \rightarrow \text{Cl}_2(\text{g}) + 2\text{e}^-$ 1 mark
- ii. $c_1 V_1 = c_2 V_2$
 $4.0 \times 50.0 = 10.0 \times V_2$
 $V_2 = 20.0 \text{ mL}$ 1 mark
- b. i. $n(\text{Cl}_2) = \frac{m}{M} = \frac{1.46}{71.0} = 0.0206 \text{ mol}$ in 100 g (100 mL) of water 1 mark
- $c(\text{Cl}_2) = \frac{n}{V} = \frac{0.0206}{0.100} = 0.206 \text{ M}$ 1 mark
- ii. decreased 1 mark
- c. For constant n and T , $p_1 V_1 = p_2 V_2$
- Partial pressure of Cl_2 from tank B when moved to tank A = $120 \times \frac{2000}{5000} = 48 \text{ kPa}$ 1 mark
- Final pressure in tank A = $150 + 48 = 198 \text{ kPa}$ 1 mark
- d. i. $\text{Al}^{3+}(\text{aq}) + 3\text{OH}^-(\text{aq}) \rightarrow \text{Al}(\text{OH})_3(\text{s})$ 1 mark
- ii. Chlorination destroys bacteria and removes biological contaminants. 1 mark
- e. High-energy, ultraviolet radiation from the sun is damaging to living organisms. 1 mark
- The ozone layer can absorb some of this radiation and so acts as a protective filter preventing widespread skin cancer in humans, for example. 1 mark

Question 3

- a. i. $\text{X}(\text{s}) + \text{Cu}^{2+}(\text{aq}) \rightarrow \text{X}^{2+}(\text{aq}) + \text{Cu}(\text{s})$ 1 mark
- ii. Cu (*reduction occurs at the cathode*) 1 mark
- iii. Cu (*electrons flow towards the positive electrode*) 1 mark
- iv. towards X (*anions flow into the X half cell to balance the accumulating positive charge*) 1 mark
- v. For example, Pb (*any metal below Cu in the electrochemical series*) 1 mark
- b. $\text{Cu}(\text{s}) + 2\text{Ag}^+(\text{aq}) \rightarrow \text{Cu}^{2+}(\text{aq}) + 2\text{Ag}(\text{s})$
- $n(\text{Ag}) = \frac{m}{M} = \frac{2.5}{107.9} \text{ mol}$ 1 mark
- $n(\text{Cu}) = \frac{1}{2} \times n(\text{Ag})$ 1 mark
- $m(\text{Cu}) = n \times M = \frac{1}{2} \times \frac{2.5}{107.9} \times 63.5 = 0.74 \text{ g}$ 1 mark

Question 4

- a. i.** Water is heated and water molecules evaporate, leaving ions in the remaining liquid. 1 mark
Water vapour leaves the flask, enters the condenser and is cooled. Water molecules condense and pure liquid water is collected. 1 mark
- ii.** Reduced air pressure above the saltwater lowers the temperature required to boil the water. 1 mark
Thus, less energy is needed to heat the water, producing freshwater at a lower cost. 1 mark
- b. i.** 3.1 g of NaCl per 100 mL of solution
 $\frac{3.1}{58.5}$ mol of NaCl per 100 mL of solution 1 mark
 $\frac{3.1}{58.5} \times 10$ mol of NaCl per 1000 mL of solution
0.53 M 1 mark
- ii.** Removing the solvent (water) from a solution of ions means that the concentration of the solute (ions) increases. 1 mark
- c. i.** Lowering the boiling point of the saltwater by reducing atmospheric pressure increases energy efficiency. 1 mark
- ii.** The desalination process uses coal-fired power station electricity. This produces pollutant carbon dioxide when coal is burnt to generate the electrical energy. 1 mark

Question 5

- a.** $\text{C}_6\text{H}_{12}\text{O}_6(\text{aq}) + 6\text{O}_2(\text{g}) \rightarrow 6\text{CO}_2(\text{g}) + 6\text{H}_2\text{O}(\text{l})$ 2 marks
1 mark for correct reactants/products
1 mark for correct states and balancing
- b.** $2\text{C}_2\text{H}_6(\text{g}) + 7\text{O}_2(\text{g}) \rightarrow 4\text{CO}_2(\text{g}) + 6\text{H}_2\text{O}(\text{g})$ 2 marks
1 mark for correct reactants/products
1 mark for correct states and balancing
- c.** 0.035 mL of CO_2 in 100 mL of air
0.35 mL of CO_2 in 1000 mL of air
 $\frac{0.35}{24500}$ mol of CO_2 in 1000 mL of air at SLC 1 mark
 $\frac{0.35}{24500} \times 44.0$ g of CO_2 in 1000 mL of air at SLC
 6.3×10^{-4} g or 0.63 mg 1 mark
- d.** There is an increase in the temperature of the atmosphere, land and waterways due to more heat energy being trapped by the atmosphere. 1 mark
This higher level of heat is trapped by an increased concentration of greenhouse gases such as carbon dioxide. 1 mark
- e.** The trees cleared are burnt, left to decay or used as timber products, all of which add carbon dioxide to the atmosphere. 1 mark
Removal of trees results in less photosynthesis, which allows more of the carbon dioxide to remain in the atmosphere. 1 mark

- f. In Reaction III, one mole of carbon dioxide is produced for each mole of calcium carbonate decomposed. In Reaction I, one mole of carbon dioxide is used for each mole of calcium carbonate produced. 1 mark

Using the calcium hydroxide to absorb carbon dioxide in waste gases simply recycles the carbon dioxide and will not reduce its concentration in the atmosphere. 1 mark