Neap:

Trial Examination 2014

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**

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Question 1 B

The unusual properties of water are mostly the result of the hydrogen bonding between the molecules, i.e. the intermolecular bonding is responsible for the high specific heat capacity, the lower density in ice and the high latent heat of vapourisation (statements I, II and IV). The covalent bonding which holds the atoms in the water molecules to each other is very strong and requires a large amount of energy to disrupt, as evidenced by statement III.

Question 2 D

Sulfuric acid is a strong diprotic acid. The first ionisation of the acid produces 1 mole of H_3O^+ ions and 1 mole of HSO_4^- ions for each 1 mole of H_2SO_4 which ionises. The solution will contain virtually no H_2SO_4 molecules, i.e. H_2SO_4 is not an abundant species, and so **A** and **C** are not the correct response. The second ionisation of the acid produces less than 1 mole of H_3O^+ ions and less than 1 mole of SO_4^{2-} ions for each 1 mole of HSO_4^- ions present. The solution will contain both HSO_4^- ions and SO_4^{2-} ions, and H_3O^+ ions will be present in greater concentration than SO_4^{2-} ions. As with most aqueous solutions, water is in the greatest concentration at about 56 M, and so **D** is the required response.

Question 3 C

1 mole (28 g) of N_2 occupies 22.4 L at STP.

$$\text{density} = \frac{m}{V} = \frac{28}{22.4} = 1.25 \text{ g L}^{-1}$$

Question 4 C

The concentration of ions in a saturated solution of sodium chloride should be almost constant from 40°C to 70°C, as the solubility of sodium chloride over this temperature range is almost constant. Therefore **C** is correct. The electrical conductivity of a solution would be expected to change with increasing temperature from 10°C to 90°C, as there is a small change in solubility over this temperature range. In addition, it would be expected that conductivity would show some change as a result of increased ion movement with increasing temperature. **D** is incorrect. Adding salt crystals to a saturated solution will not produce an unsaturated solution, so **A** is not correct. The solubility is almost constant over the temperature range 60°C to 80°C, so cooling from 80°C to 60°C will not cause much sodium chloride to come out of solution. **B** is incorrect.

Question 5 B

At 60°C, 40 g of NaCl dissolves in 100 g of water.

Therefore 400 g dissolves in 1000 g = 1000 mL of water.

400 g of NaCl is not 400 or 200 g of chloride ion, and so **C** and **D** are incorrect.

400 g of NaCl per 1 litre of water is $\frac{400}{58.5}$ mol of NaCl per 1 litre of water, i.e. 6.8 M.

$[Cl^-] = [NaCl] = 6.8$ M

Question 6 D

Distillation does not rely on the solubility of a solute, but on the ability of water to evaporate, leaving the solute to remain in the heated solution. Neither **A** nor **B** is correct. As water is evaporating, the concentration of the heated solution will increase, and so **D** is correct. Water will evaporate at less than 100°C, especially if the atmospheric pressure is reduced (as happens in flash distillation), and so **C** is incorrect.

Question 7 **A**

Sodium hydroxide is a strong base and nitric acid is a strong acid.

Question 8 **B**

The straight lines in the graph intersect at 25 mL of nitric acid. The stoichiometric ratio is 1 : 1.

$n(\text{NaOH}) = c \times V = 0.80 \times 0.0200$ mol

$n(\text{NaOH}) = n(HNO_3)$

$c(HNO_3) = \frac{n}{V} = \frac{0.80 \times 0.0200}{0.025} = 0.64$ M

Question 9 **C**

Reaction with base to produce salt and water shows that X is acidic. Reaction with acid to produce salt, water and carbon dioxide shows that X is a carbonate or hydrogen carbonate ion, i.e. a base. Thus X is amphiprotic.

Question 10 **B**

In a solution of pH 4, $[H_3O^+] = 10^{-\text{pH}} = 10^{-4}$.

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

$[OH^-] = \frac{10^{-14}}{10^{-4}} = 10^{-10}$ M

Acidic solutions have a mix of hydrogen ions and hydroxide ions. **A** is incorrect.

Question 11 **D**

$O_2 + 2H_2O + 4e^- \rightarrow 4OH^-$ $\quad$ $Fe \rightarrow Fe^{2+} + 2e^-$

The oxidant is oxygen, the reductant is iron.

Question 12 **A**

A reactant in the equation is oxygen and so removal of oxygen would decrease the level of corrosion. **A** is correct. The results show that the higher the hydrogen ion concentration (i.e. the lower the pH), the greater the extent of corrosion. **B** is incorrect. The information provided does not allow a conclusion to be reached regarding corrosion at temperatures other than 25°C, or at pH values above 7. **C** is incorrect. The acidity of the solution is not halved by halving the pH from 6 to 3 – the acidity (or hydrogen ion concentration) is increased by a factor of 1000. **D** is therefore incorrect.

Question 13 **D**

$n = \frac{pV}{RT}$ and, as T is constant, the number of mole is dependent on the product pV. As flask X has a smaller product pV (10) than for flask Y (80), it has fewer particles of gas. Statement I is thus correct. In either flask there is a significant spread of speeds of particles. Statement II is incorrect. The temperature of a gas is a measure of the average kinetic energy of the particles, irrespective of the identity of the gas. As the temperature is constant for both gases, statement III is correct. With statements I and III correct, **D** is the required response.

Question 14 A

At constant temperature, $p_1V_1 = p_2V_2$.

When the tap is opened, $p(\text{Ne}) = \frac{5 \times 2}{10} = 1$ atm and $p(\text{Ar}) = \frac{10 \times 8}{10} = 8$ atm.

Therefore total pressure = 9 atm.

Question 15 A

concentrated = large number of molecules initially (in a given volume). **B** and **D** are incorrect.

weak acid = small number of molecules ionise. Hence **A** is correct, not **C**.

Question 16 B

The zinc coating is impervious to air and water and thus acts as a physical barrier. Statement I is correct. As zinc is a more reactive metal than iron, a scratch which exposes the iron surface will not cause corrosion of iron as the zinc will be oxidised preferentially to produce zinc ions. Statement II is incorrect, whereas statement III is accurate. With I and III correct, **B** is the required response.

Question 17 A

0.035 mol of $Cr_2O_7^{2-}$ will react with $6 \times 0.035 = 0.210$ mol of I^-.

With only 0.19 mol of I^- available, I^- is the limiting reagent.

0.19 mol of I^- will produce $\frac{3}{6} \times 0.19 = 0.095$ mol of I_2.

Question 18 C

Two green chemistry objectives are to use renewable raw materials and to eliminate the generation of by-products, particularly toxic ones. So features I and II are not applications of the principles of green chemistry. Increased energy efficiency (IV) and use of catalysts (III) are also green chemistry objectives, and so **C** is the correct answer.

Question 19 C

I, II and III are problems caused by depletion of the ozone layer allowing more ultraviolet radiation to reach the surface of the planet. IV is a problem of climate change related to the enhanced greenhouse effect.

Question 20 D

Methane gas is emitted from the degradation of plant material by bacteria in rubbish dumps, but the main source of methane is rice paddies and the digestive systems of ruminants, i.e. agriculture.

SECTION B: SHORT-ANSWER QUESTIONS

Question 1 (12 marks)

a. i. Nitrogen is extracted from air. 1 mark

ii. $n(H_2) = \frac{m}{M} = \frac{150\ 000}{2}$ mol 1 mark

$n(NH_3) = \frac{2}{3} \times n(H_2) = \frac{2}{3} \times \frac{150\ 000}{2} = 50\ 000$ mol 1 mark

$V(NH_3) = \frac{nRT}{p} = \frac{50\ 000 \times 8.31 \times 293}{100}$ 1 mark

$= 1.2 \times 10^6$ L 1 mark

b. i. *For example, one of:*

- Ammonia is a gas at room temperature and thus would need to be compressed or liquefied so that a substantial amount could be delivered to the farm, and this involves added costs.
- Transporting hazardous gases poses dangers should accidents occur. Release of the gas into the environment may cause injury to people.

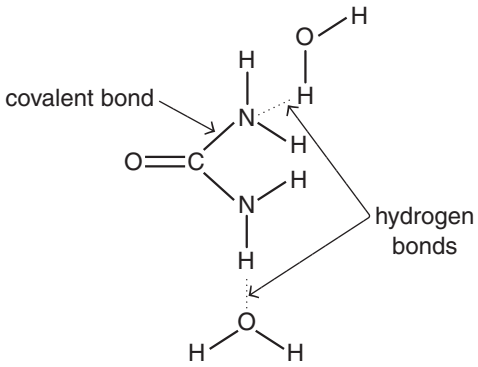
1 mark

ii. *For example, one of:*

- Unless it quickly dissolved in soil water, the volatile ammonia would be released from the soil. This would be wasteful and dangerous.
- Ammonia may affect microorganisms in the soil, reducing soil fertility.

1 mark

c. i. Urea is a small molecule which is capable of forming hydrogen bonds with water because of the polarity of the N–H covalent bonds. 1 mark



2 marks
1 mark for drawing and placement of water molecules
1 mark for labelling of two bond types

ii. $\%N = \frac{m(N)}{m(\text{urea})} \times 100 = \frac{2 \times 14.0}{60.0} \times 100 = 46.7\%$ 1 mark

iii. Ammonia is a weak base and so will make the soil alkaline, increasing its pH. 1 mark

Question 2 (11 marks)

a. Releasing sulfur dioxide from burning coal can cause 'acid rain' when the gas dissolves in rainwater, producing rain that is acidic enough to damage buildings, plant life and metallic structures. 1 mark

$SO_2(g) + H_2O(l) \rightarrow H_2SO_3(aq)$ 1 mark

b. $n(CaCO_3) = \frac{m}{M} = \frac{10^6}{100.1}$ mol 1 mark

$n(CaSO_4 \cdot 2H_2O) = n(CaCO_3) = \frac{10^6}{100.1}$ mol 1 mark

$m(CaSO_4 \cdot 2H_2O) = n \times M = \left(\frac{10^6}{100.1} \times 172.2\right) = 1.72 \times 10^6$ g = 1.72 tonnes 1 mark

c. **i.**

Removing carbon dioxide gas from the atmosphere	Green plants use carbon dioxide and water in the presence of sunlight to produce oxygen and complex organic compounds (photosynthesis).
Releasing carbon dioxide gas into the atmosphere	Natural decomposition of plant and animal matter releases carbon dioxide. **OR** Plants and animals release carbon dioxide during respiration (combustion of fuel within the body).

2 marks

ii.

Procedures	**Will the procedure remove the 'hardness' of the water? (Write YES or NO)**	**Explanation**
Distillation	yes	On boiling, the water vapour passes into a condenser and pure water is collected, leaving the ions behind.
Filtration using ordinary filter paper	no	The dissolved compound will pass through the pores in ordinary filter paper and so the filtrate will also contain $Ca(HCO_3)_2$.
Reverse osmosis	yes	The compound causing the hardness of the water will not pass through the membrane which allows water through.
Boiling	yes	Calcium ions will form a precipitate of $CaCO_3$ which will sediment and pure water can be poured off.

4 marks

1 mark each for a correct 'yes' and a correct 'no'
1 mark each for the two correct corresponding explanations

Question 3 (9 marks)

a. **i.** $Ni(s) + 2Fe^{3+}(aq) \rightarrow Ni^{2+}(aq) + 2Fe^{2+}(aq)$ 1 mark

ii. $Fe^{3+}(aq)$ 1 mark

iii. Ni 1 mark

iv. X 1 mark

v. C or Pt 1 mark

b. **i.** $n(Ni(NO_3)_2) = \frac{m}{M} = \frac{4.75}{182.7}$ mol 1 mark

$n(NO_3^-) = 2 \times n(Ni(NO_3)_2) = 2 \times \frac{4.75}{182.7}$ mol 1 mark

$c(NO_3^-) = \frac{n}{V} = \frac{2 \times 4.75}{182.7 \times 0.250} = 0.208$ M 1 mark

ii. increase *(anions flow from beaker II to beaker I as the cell operates)* 1 mark

Question 4 (15 marks)

a.

Method of preparation	Name of gas
A solution of ammonium nitrate is boiled vigorously.	nitrogen
Manganese(IV) oxide is added to hydrogen peroxide solution.	oxygen
Cold 50% nitric acid is used to reduce copper metal.	nitrogen(II) oxide
Solid calcium carbonate is reacted with hydrochloric acid.	carbon dioxide
Copper metal is reacted with concentrated nitric acid.	nitrogen(IV) oxide

1 mark

1 mark for one gas preparation correctly identified

b. **i.** At STP, 0.0069 g of oxygen will dissolve in 100 g of water.

$n(O_2) = \frac{m}{M} = \frac{0.0069}{32.0}$ mol 1 mark

$V(O_2)$ at STP $= n \times V_M = \frac{0.0069}{32.0} \times 22.4 = 4.83 \times 10^{-3}$ L $= 4.8$ mL 1 mark

ii. 0.0011 g of methane will dissolve in 100 g, and so:

4.5×0.0011 g will dissolve in 450 g of water. 1 mark

$n(CH_4) = \frac{m}{M} = \frac{4.5 \times 0.0011}{16.0} = 3.09 \times 10^{-4}$ mol 1 mark

number of CH_4 molecules $= n \times N_A = 3.09 \times 10^{-4} \times 6.02 \times 10^{23} = 1.9 \times 10^{20}$ 1 mark

iii. The solubility of potassium nitrate increases with increasing temperature 1 mark

OR

The solubility is in tens of grams per 100 g of water rather than the fraction of a gram for most of the gases. 1 mark

iv. HCl will ionise fully in water according to the equation:

$HCl(g) + H_2O(l) \rightarrow H_3O^+(aq) + Cl^-(aq)$ 1 mark

There are charged particles (ions) present to carry electrical charge through the solution, and so HCl(aq) conducts. 1 mark

c. **i.** $2Mg(s) + O_2(g) \rightarrow 2MgO(s)$ 1 mark

ii. $O_2 + 4e^- \rightarrow 2O^{2-}$ 1 mark

iii. There must be 50 – 34 = 16 mL of oxygen gas. 1 mark

$$\% \text{ oxygen in sample} = \frac{16}{50} \times 100 = 32\%$$ 1 mark

iv. From the table of gas solubilities it can be seen that the solubility of oxygen is more than twice the solubility of nitrogen. 1 mark

So even though the atmosphere contains about 20% oxygen, a much higher percentage could be expected to be dissolved in water. 1 mark

Question 5 (8 marks)

a. $2NO(g) + O_2(g) \rightarrow 2NO_2(g)$ 1 mark

b. **i.** As the gas is heated, the gas particles increase in speed and collide with the walls of the gas syringe more often and with greater force. 1 mark

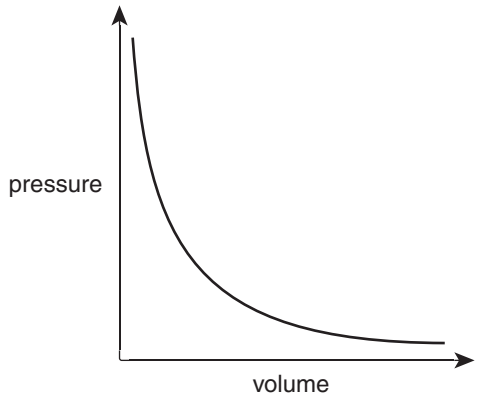
As the plunger is being pushed from the outside with atmospheric pressure and there is greater pressure inside the syringe, the plunger will move outwards. 1 mark

ii. At constant pressure, $\frac{V_1}{T_1} = \frac{V_2}{T_2}$. 1 mark

$$\frac{40}{293} = \frac{V_2}{313}$$

$V_2 = 43$ mL 1 mark

iii.



1 mark

c. **i.** *Any one of:*

- windless days
- sunlight
- temperature inversion
- unburnt hydrocarbons
- oxygen gas

1 mark

ii. increased incidence of respiratory problems or stunted plant growth 1 mark

