Neap:

Trial Examination 2011

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 **C**

$$c_1V_1 = c_2V_2$$

$$0.340 \times 150 = 0.204 \times V_2$$

$$V_2 = 250 \text{ mL}$$

The question asks for the volume of water which must be added to the initial solution, and so the answer is 100 mL (i.e. 250 – 150).

Question 2 **A**

Using $\frac{p_1V_1}{T_1} = \frac{p_2V_2}{T_2}$ gives $p_2 = \frac{p_1V_1T_2}{V_2T_1} = \frac{100 \times 50 \times 313}{100 \times 293} = 53.4 \text{ kPa}$.

This is closest to alternative **A**.

Question 3 **B**

The strongest oxidant present is the hydrogen ion, H^+. This will react with the strongest reductant present, Pb. The equation for the reaction is

$$2H^+(aq) + Pb(s) \rightarrow H_2(g) + Pb^{2+}(aq)$$

Hydrogen gas (colourless and odourless) is evolved, and the lead strip dissolves. Therefore **B**, not **D**, is the correct response. The Ni^{2+} ion does not react, so the solution colour does not alter. **A** is not the correct response. All nitrate salts are soluble, so lead(II) nitrate will not precipitate. **C** is not the correct response.

Question 4 **B**

$$n(Ca(OH)_2) = c \times V = 0.0200 \times 0.500 = 0.0100 \text{ mol}$$

$$n(CO_2) = 2 \times n(Ca(OH)_2) = 0.0200 \text{ mol}$$

$$V(CO_2) \text{ at SLC} = n \times V_M = 0.0200 \times 24.5 = 0.490 \text{ L}$$

Question 5 **D**

Water molecules will be present in the highest number of any chemical species in an aqueous solution. **A** and **C** are incorrect. After water molecules, the phosphoric acid molecules will be the next most prevalent as the degree of ionisation diminishes in each successive hydrolysis reaction. Thus **B** is incorrect and **D** is the required answer.

Question 6 **D**

As HCl is a strong acid, the reaction with water will involve complete ionisation. Being a weak acid, H_3PO_4 will ionise partially. Thus the pH of the HCl solution will be lower than that of H_3PO_4. Statement I is not correct. The reactions of the acids with the strong base NaOH will go to completion. As H_3PO_4 has three ionisable protons, it will require a higher volume of strong base than HCl. Statement II is incorrect. As neither statement I nor II is correct, **D** is the required response.

Question 7 **A**

At 90°C, 162 g of $NaNO_3$ dissolves in 100 mL (100 g) of water.

At 40°C, 100 g of $NaNO_3$ dissolves in 100 mL (100 g) of water.

As the solution is cooled, 62 g of $NaNO_3$ will crystallise from solution.

However, we have only 70 mL of a saturated solution, and so the amount to crystallise will be

$\frac{70}{100} \times 62 = 43$ g

This is closest to alternative **A**, 40 g.

Question 8 **A**

Relevant relationships are:

$V \propto n$ at constant *T* and *p*. This is correctly shown in the graph in alternative **A**.

$p \propto n$ at constant *T* and *V*. This is incorrectly shown in the graph in alternative **B**.

pV is constant at constant *T* and *n*. This is incorrectly shown in the graph in alternative **C**.

$V \propto T$ at constant *n* and *p*. This is incorrectly shown in the graph in alternative **D**.

Question 9 **B**

$[H_3O^+] = 10^{-pH} = 10^{-7.5}$

As it is pure water, the concentration of hydroxide ions is $10^{-7.5}$ M, equal to the concentration of hydronium ions. Thus **A** and **C** are incorrect. Pure water is neutral irrespective of its pH. pH is temperature-dependent. **D** is incorrect and **B** is the required response.

Question 10 **C**

As the temperature and pressure remain constant, $n \propto V$. From the equation, 120 mL of HCl will react with 30 mL of O_2 with 20 mL unreacted. The products will each occupy 60 mL. After the reaction, total gas volume = 60 + 60 + 20 = 140 mL.

Question 11 **B**

There are 'negligible' forces of attraction between gas particles, so statement I is incorrect. The average kinetic energy of gas particles is proportional to the absolute temperature of the gas, not to the pressure of the gas. Statement III is incorrect. Statements II and IV are correct, so **B** is the required response.

Question 12 **B**

The first result indicates that P is more reactive than S, but less reactive than Q. The second result indicates that Q is more reactive than S, but less reactive than R. Thus the order of reactivity, starting with the most reactive, is R, Q, P, S.

Question 13 **A**

Oxidation occurs at the anode, so alternatives **C** and **D** are incorrect. In the galvanic cell constructed using the P and R half-cells, the most reactive metal, R, will reduce the most reactive metal ion, P^{2+}. Thus at the anode, oxidation of metal R will occur.

$R(s) \rightarrow R^{2+}(aq) + 2e^-$

Question 14 C

The gas pressure in cylinder P results from the oxygen gas and the water vapour present. Thus **A** is not correct. As oxygen gas is delivered into cylinder P, the water level in it will drop. The water level in the trough Q will therefore rise. **B** is incorrect. Oxygen is prepared industrially by the fractional distillation of liquid air and so **D** is incorrect. Increasing the concentration of the reactant will increase the rate of the reaction. **C** is correct and so is the required response.

Question 15 D

$$n(\mathrm{O_2}) = \frac{m}{M} = \frac{1.0}{32} \text{ mol}$$

$$n(\mathrm{N_2}) = \frac{m}{M} = \frac{1.0}{28} \text{ mol}$$

The number of mole of oxygen molecules, and hence the number of oxygen molecules, is less than that of nitrogen molecules. Alternatives **A** and **B** are incorrect.

Both flasks have the same temperature and so the average kinetic energy of molecules in the both flasks is the same.

$$\text{KE(oxygen molecules)} = \frac{1}{2} \times 32 \times v_1^2 = \text{KE(nitrogen molecules)} = \frac{1}{2} \times 28 \times v_2^2$$

Therefore v_1 must be less than v_2. Alternative **D** is the required response.

Question 16 D

Coating the iron in a more reactive metal such as manganese would provide sacrificial protection. Impressed current will prevent the iron from being oxidised. Removing water from the air in contact with the iron will remove a reactant from the equation and prevent it from occurring. Thus **A**, **B** and **C** will be effective methods of protecting the iron from rusting. Forming a barrier by coating with a less reactive metal such as tin will prevent corrosion because it prevents oxygen and water contacting the iron surface. Electrically connecting a less reactive metal to the iron will result in the iron rusting at a more rapid rate because, in effect, it becomes the sacrificial anode. Alternative **D** is thus the correct answer.

Question 17 C

The nitrate ions in the salt bridge are flowing into beaker II to replace lost negative charge. This means that electrons must flow away from beaker II as the current flows. Oxidation must be occurring at the electrode in beaker II. As Fe is a stronger reductant than Pb, it is the Fe that is being oxidised in beaker II. In beaker I, reduction of the oxidant $Pb^{2+}(aq)$ must be occurring.

Question 18 C

Oxidation is occurring at the electrode in beaker II. This electrode is therefore the anode and is negatively charged due to the production of electrons at its surface.

Question 19 D

As the temperature and pressure are the same for both flasks, the number of mole in each flask must be identical.

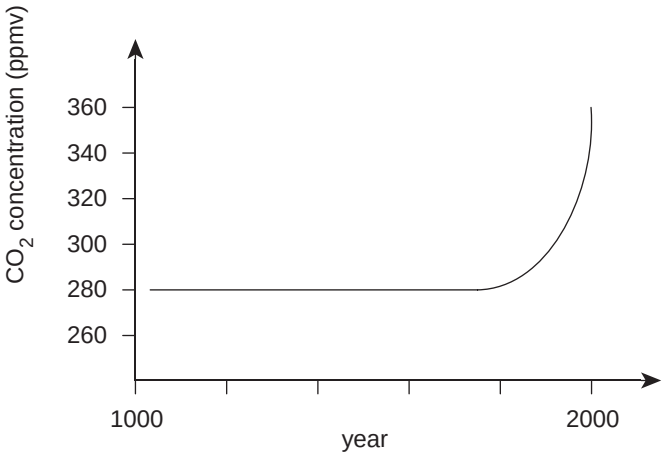
$$n(\mathrm{N_2}) = \frac{m}{M} = \frac{0.042}{28} = n(\text{hydrocarbon}) = \frac{0.108}{M}$$

$$M = 72 \text{ g mol}^{-1}$$

Pentane, C_5H_{12} has this molar mass.

Question 20 A

The graphs in **B**, **C** and **D** correctly show changes in concentrations and temperature with time and altitude. The graph in **A** incorrectly shows a gradual increase in CO_2 concentration over a 1000 year time span. This graph should look like the one shown below.



SECTION B: SHORT-ANSWER QUESTIONS

Question 1

a. i. Ammonia is very soluble in water and thus the vapour dissolves, lowering the gas pressure in the upper flask. 1 mark

Atmospheric pressure pushes the water up tube A into the upper flask. 1 mark

ii. $NH_3(g) + H_2O(l) \rightleftharpoons NH_4^+(aq) + OH^-(aq)$ 1 mark

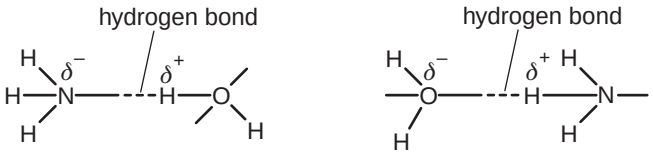
Ammonia reacting with water produces a basic solution which will change the colour of the indicator to pink. 1 mark

iii. $n(NH_3) = \dfrac{pV}{RT} = \dfrac{100 \times 0.2500}{8.31 \times 293} = 1.03 \times 10^{-2}$ mol 2 marks

1 mark for correct conversion of units
1 mark for correct use of gas equation

$m(NH_3) = n \times M = 1.03 \times 10^{-2} \times 17.0 = 0.175$ g 1 mark

b. **i.** Both ammonia and water are polar molecules. They form intermolecular hydrogen bonds, resulting in the high solubility of ammonia. 1 mark



2 marks
1 mark for correct drawing of molecules
1 mark for correct labelling of bonds

ii. Sulfur dioxide gas in the atmosphere will dissolve in rainwater to produce sulfurous acid $(SO_2(g) + H_2O(l) \rightarrow H_2SO_3(aq))$. This will produce rain with lower pH than normal. 1 mark

This 'acid rain' can kill plants and lowers the pH of natural waterways which may cause destruction of the natural habitat. 1 mark

iii. Heated water has a lower concentration of oxygen. 1 mark

Lower oxygen concentration in natural waterways will impair functioning of aquatic life, possibly killing some species and disrupting the natural habitat. 1 mark

Total 14 marks

Question 2

a. **i.** Ca and H_2O (*react to form hydrogen gas*) 1 mark

ii. H_2O and OH^- 1 mark

iii. Ar 1 mark

iv. NO 1 mark

b. **i.** I 1 mark

ii. II and III 1 mark

iii. III 1 mark

iv. IV 1 mark

Total 8 marks

Question 3

a. **i.** At any temperature, particles of water have a range of energies. 1 mark

Within this range, some molecules will have enough energy to escape the liquid phase to produce water vapour. 1 mark

ii. *Any one of:*

- distillation under reduced pressure
- use of an ion-exchange resin
- reverse osmosis
- distillation

1 mark

b. **i.** pH decreases 1 mark

The reaction produces hydrogen ions, resulting in the lowering of the pH. 1 mark

ii. A weak acid only ionises partially in its reaction with water. 1 mark

iii. $Cl_2(g) + 2e^- \rightarrow 2Cl^-(aq)$ 1 mark

c. **i.** 2.0×10^2 L = $2.0 \times 10^2 \times 10^3$ g of water 1 mark

61 ppm is 61 g of $CaCO_3$ in 10^6 g of water

$\therefore$ 12 g of $CaCO_3$ in 2.0×10^5 g of water 1 mark

ii. Natural rainwater is acidic (as carbon dioxide from the air will dissolve in it producing a weak acid).

This acid reacts with the calcium carbonate and so dissolves it. 1 mark

iii. $Ca^{2+}(aq) + CO_3^{2-}(aq) \rightarrow CaCO_3(s)$ 1 mark

Total 11 marks

Question 4

a. burette (or graduated pipette) 1 mark

b. **i.** $n(Ba(OH)_2) = c \times V = 0.050 \times 0.1000 = 5.0 \times 10^{-3}$ mol 1 mark

$m(Ba(OH)_2) = n \times M = 5.0 \times 10^{-3} \times 171.3 = 0.86$ g 1 mark

ii. Barium hydroxide solid consists of barium ions and hydroxide ions bonded together in a lattice. Dissolving in water breaks the bonds between the ions and allows them to move independently so that charge is carried in the solution. 1 mark

c. **i.** $Ba(OH)_2(aq) + H_2SO_4(aq) \rightarrow BaSO_4(s) + 2H_2O(l)$ 2 marks

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

d. **i.** 5.5 mL 1 mark

ii. $n(Ba(OH)_2) = c \times V = 0.050 \times 0.0200 = 0.0010$ mol 1 mark

$n(Ba(OH)_2) = n(H_2SO_4) = 0.0010$ mol 1 mark

$c(H_2SO_4) = \frac{n}{V} = \frac{0.0010}{0.0055} = 0.18$ M 1 mark

Total 10 marks

Question 5

a. i. Atmospheric nitrogen is converted to a soluble nitrogen compound which can be used by plants. 1 mark

ii. The high temperatures generated by lightning (or volcanoes) cause nitrogen to react with oxygen in the atmosphere to form nitrogen(II) oxide. 1 mark

b. i. Air is 78% nitrogen and costs nothing, whereas using pure nitrogen would be expensive. 1 mark

ii. In 100 mL there are 68 g of HNO_3

$$n(HNO_3) = \frac{m}{M} = \frac{68}{63} \text{ mol}$$

$$c(HNO_3) = \frac{n}{V} = \frac{68}{63 \times 0.100} = 10.8 \text{ M}$$

1 mark

As HNO_3 is a strong monoprotic acid $[H^+] = [HNO_3] = 10.8$ M 1 mark

$pH = -\log_{10}[H^+] = -\log_{10}10.8 = -1.0$ 1 mark

iii. $2HNO_3(aq) + Na_2CO_3(s) \rightarrow 2NaNO_3(aq) + H_2O(l) + CO_2(g)$ 2 marks

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

c. i. $M(NH_3) + M(2O_2) = 17 + 64 = 81$; $M(HNO_3) = 63$ 1 mark

% atom economy $= \frac{63}{81} \times 100 = 78\%$ 1 mark

ii. *Any two of:*

- using a catalyst
- minimising energy losses by recycling waste heat
- recycling unreacted gases

2 marks

Total 12 marks

