VCE CHEMISTRY 2011

YEAR 11 TRIAL EXAM UNIT 2

Time allowed: 90 Minutes
Total marks: 76

Section A
Contains 24 Multiple Choice Questions
24 marks, 28 minutes

Section B
Contains 6 Short Answer Questions
52 marks, 62 minutes

To download the Chemistry Data Book please visit the VCAA website:
http://www.vcaa.vic.edu.au/vce/studies/chemistry/chem1_sample_2008.pdf *Page 20*

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Student Name....…………………………...

VCE Chemistry 2011 Year 11 Trial Exam Unit 2

Student Answer Sheet

There are 24 Multiple Choice questions to be answered by circling the correct letter in the table below. Use only a 2B pencil. If you make a mistake, erase and enter the correct answer. Marks will not be deducted for incorrect answers

Question 1	A	B	C	D	*Question 2*	A	B	C	D
Question 3	A	B	C	D	*Question 4*	A	B	C	D
Question 5	A	B	C	D	*Question 6*	A	B	C	D
Question 7	A	B	C	D	*Question 8*	A	B	C	D
Question 9	A	B	C	D	*Question 10*	A	B	C	D
Question 11	A	B	C	D	*Question 12*	A	B	C	D
Question 13	A	B	C	D	*Question 14*	A	B	C	D
Question 15	A	B	C	D	*Question 16*	A	B	C	D
Question 17	A	B	C	D	*Question 18*	A	B	C	D
Question 19	A	B	C	D	*Question 20*	A	B	C	D
Question 21	A	B	C	D	*Question 22*	A	B	C	D
Question 23	A	B	C	D	*Question 24*	A	B	C	D

VCE Chemistry 2011 Year 11 Trial Exam Unit 2

SECTION A – Multiple Choice Questions

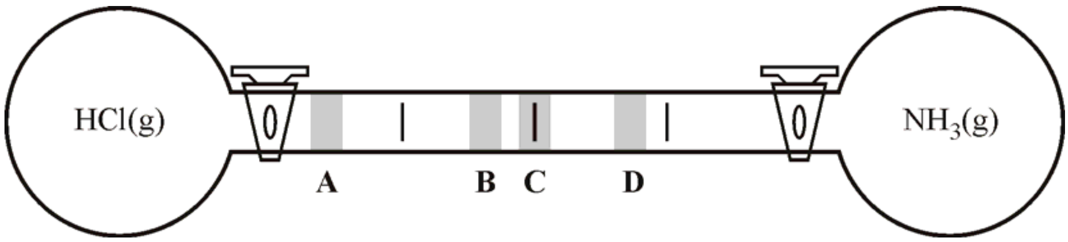
(24 marks, 28 minutes)

This section contains 24 multiple choice questions.
For each question, choose the response that is correct or best answers the question.
Indicate your answer on the answer sheet provided.
*(Choose only **one** answer for each question.)*

Question 1
The products that would form when stoichiometric amounts of 2 M aqueous hydrochloric acid solution and solid potassium carbonate are mixed will be
A. CO_2(g) and H_2O(l).
B. CO_2(g), H_2O(l) and KCl(s).
C. KCl(aq), H_2O(l) and CO_2(g).
D. KCl(aq), CO_2(l) and H_2O(l).

Question 2
Methanol is completely miscible, dissolves completely, in water. This is due to
A. the formation of ion-dipole interactions that result when methanol ionises in water.
B. hydrogen bonds forming between the water molecules and the methyl groups in methanol.
C. the formation of dispersion forces between the water and methanol molecules.
D. the hydroxy groups in methanol forming hydrogen bonds with the water molecules.

Question 3
Ammonia and hydrogen chloride gases react to form solid ammonium chloride. The apparatus shown in the diagram below was set up with both separate gas samples at SLC. The two taps were opened at the same time and the gases were allowed to diffuse through the central tube joining the two flasks.



The position along the central tube where the solid ammonium chloride would first form would be
A. position A.
B. position B.
C. position C.
D. position D.

Question 4

Nitrogen gas is extensively used in industry. The industrial production of nitrogen gas involves

A. the fractional distillation of liquid air.
B. collecting the by-product from the fermentation of sugars.
C. passing steam over heated finely divided iron.
D. passing air over red hot carbon.

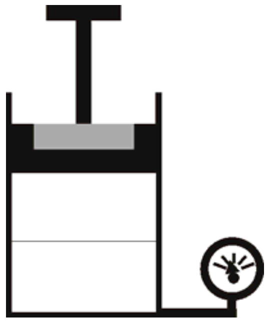
Question 5

50.00 mL of an aqueous 0.0100 M calcium hydroxide, $Ca(OH)_2$, solution is added to 950.0 mL of deionised water and thoroughly mixed. The pH of the resultant solution will be closest to

A. 10.7
B. 3.3
C. 11.0
D. 3.0

Question 6

A sample of gas in a piston is maintained at constant temperature while the piston is pushed so that the gas now occupies half its original volume.



The pressure exerted by the gas will now be

A. less than half its original value.
B. exactly twice its original value.
C. more than half its original value.
D. exactly half its original value.

Question 7

The solubility of potassium chloride in water at 25 °C and 50 °C is 36.10 g/100.0 mL and 42.80 g/100.0 mL respectively. A student filtered a 500.0 mL sample of a saturated potassium chloride solution at 25 °C. What is the minimum mass of solid potassium chloride that the student would need to add to this sample to ensure that the sample was saturated when it was heated to 50 °C?

A. 214 g.
B. 6.70 g.
C. 181 g.
D. 33.5 g.

Question 8

The enhanced greenhouse effect is due to pollutant gases such as carbon dioxide and methane in the atmosphere

A. not absorbing ultraviolet radiation coming from the Sun.
B. absorbing infrared radiation that is reflected from the Earth's surface.
C. not absorbing infrared radiation coming from the Sun.
D. absorbing ultraviolet radiation that is reflected from the Earth's surface.

Question 9
Nitrous acid, $HNO_2(aq)$, is a weak acid. In a 100 mL sample of an aqueous 0.50 M nitrous acid solution, the relative concentrations of the species present would in decreasing order of concentration be
A. $[HNO_2] > [H_3O^+] > [NO_2^-] > [OH^-]$.
B. $[HNO_2] > [H_3O^+] = [OH^-] > [NO_2^-]$.
C. $[H_3O^+] = [NO_2^-] > [HNO_2] > [OH^-]$.
D. $[HNO_2] > [H_3O^+] = [NO_2^-] > [OH^-]$.

Question 10
A town's water supply was found to contain a fine suspension of tiny solid particles. The most appropriate treatment that the water supply authority could employ would involve
A. a flocculation process.
B. a chlorination process.
C. a distillation process.
D. an ion-exchange process.

Question 11
The thermal decomposition of mercury(II) oxide can be represented by the chemical equation

$$2HgO(s) \rightarrow 2Hg(l) + O_2(g)$$

When a sample of mercury(II) oxide was heated to constant mass, its mass decreased by 3.156 g. The mass of the original mercury(II) oxide sample was
A. 21.4 g.
B. 85.5 g.
C. 42.7 g.
D. 10.7 g.

Question 12
A sample of nitrogen at SLC occupies a volume of 1.47 L. Which one of the following gas samples, all at SLC, would occupy the same volume?
A. 0.060 g of hydrogen gas.
B. 3.61×10^{22} atoms of xenon gas.
C. 1.92 g of ozone gas.
D. 1.80×10^{22} molecules of oxygen gas.

Question 13
A 0.995 g sample of a gas occupied 750.0 mL at 102.52 kPa and 298 K. The molecular formula for the gas is most likely to be
A. O_2.
B. SO_2.
C. C_2H_7NO.
D. C_2H_6O.

Question 14
A student added an aqueous solution to an aqueous solution of barium chloride and observed the formation of a precipitate. The added solution could have contained
A. copper(II) nitrate.
B. lithium hydroxide.
C. ammonium sulfate.
D. potassium iodide.

Question 15

The reaction between aqueous solutions of ammonia and sulfuric acid can be described by the chemical equation

$$2NH_3(aq) + H_2SO_4(aq) \rightarrow (NH_4)_2SO_4(aq)$$

16.44 mL of 0.130 M sulfuric acid was required to neutralise 20.00 mL of ammonia solution. The concentration of the ammonia solution was

A. 0.260 M.
B. 0.214 M.
C. 0.107 M.
D. 0.130 M.

Question 16

One of the effects of acid rain is to stunt the growth of plants. This is because the lower pH rain water results in

A. an increase in the amounts of nitrate compounds in the soil.
B. magnesium compounds being leached from the soil.
C. an increase in the amounts of sulfate compounds in the soil.
D. phosphate ions in the soil forming insoluble compounds that the plants cannot absorb.

Question 17

The combustion of propene can be represented by the following chemical equation

$$2C_3H_6(g) + 9O_2(g) \rightarrow 6CO_2(g) + 6H_2O(l)$$

The minimum volume of oxygen gas, at SLC, required to completely burn 3.70 L of propene at SLC is

A. 11.1 L.
B. 16.7 L.
C. 12.7 L.
D. 33.3 L.

Question 18

During the wet corrosion of iron,

A. iron is reduced to iron(II) ions and oxygen is oxidised to oxide ions.
B. water is oxidised to hydroxide ions.
C. iron is oxidised to iron(II) ions and water is reduced to hydroxide ions.
D. oxygen is reduced and iron is oxidised to iron(II) ions

Question 19

The weather conditions most likely to lead to the formation of photochemical smog over a city are

A. bright sunny days with moderate winds.
B. calm wind conditions and low clouds.
C. sunny days with calm wind conditions.
D. overcast days with moderate winds.

Question 20
A sample of magnesium powder is added to an excess of an aqueous solution of sulfuric acid. The volume of dry hydrogen collected at 22.8 °C and 110.0 kPa was 956 mL. The mass of magnesium in the sample was
A. 0.909 g.
B. 1.04 g.
C. 0.520 g.
D. 2.08 g.

Question 21
The fixation of nitrogen is important for both animal and plant life. The fixation process that contributes **least** to the amount of nitrogen compounds available to plants is
A. lightning in thunder storms.
B. certain bacteria in plant root nodules.
C. the use of artificial fertilisers.
D. excreted waste from animals.

Question 22
When developing a green chemical process a chemist would aim to
A. achieve the highest product yield possible.
B. carry out the process using a continuous flow process.
C. maximise the atom economy for the reactions involved.
D. maximise the rate at which the product is formed.

Question 23
The reaction that occurs when a piece of clean magnesium metal is placed in water can be described by the chemical equation

$$Mg(s) + 2H_2O(l) \rightarrow Mg(OH)_2(s) + H_2(g)$$

In this reaction the water is acting as the
A. oxidant because it is donating electrons.
B. reductant because it is accepting electrons.
C. reductant because it is donating electrons.
D. oxidant because it is accepting electrons.

Question 24
The depletion of stratospheric ozone has mainly been attributed to the
A. increased use of fossil fuels by society.
B. release of nitrogen oxides from car and truck engines.
C. use of chlorofluorocarbons and halons.
D. release of methane from intensive agricultural practices.

End of Section A

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SECTION B – Short Answer Questions

(52 marks, 62 minutes)

This section contains six questions, numbered 1 to 6.
All questions should be answered in the spaces provided.
The mark allocation and approximate time that should be spent on each question are given.

Question 1 (12 marks, 14 minutes)

a. The hydrogen carbonate ion is amphiprotic. Write two appropriate chemical equations to represent this behaviour.

(2 marks)

b. What would be the chemical formula for the conjugate acid of the amide, NH_2^-, ion?

(1 mark)

c. i. Calculate the pH of a 0.0500 M aqueous hydrochloric acid solution.

(1 mark)

ii. The pH of a 10.00 mL sample of a 0.20 M aqueous propanoic acid, C_2H_5COOH, solution is 2.79. What does this information indicate about the strength of propanoic acid?

(1 mark)

d. Write an appropriate chemical equation for the reaction that would occur when an aqueous solution of nitric acid is added to a sample of solid manganese(IV) oxide.

(1 mark)

e. The reaction between aqueous solutions of hydrochloric acid and sodium hydroxide can be represented by the chemical equation

$$HCl(aq) + NaOH(aq) \rightarrow NaCl(aq) + H_2O(l)$$

The main constituent in a commercial cleaner used to remove excess mortar from bricks is hydrochloric acid.
A student took a 5.00 mL sample of the cleaner and carefully diluted it with deionised water until the total volume was 500.0 mL.
12.14 mL of a 0.187 M aqueous sodium hydroxide solution was required to neutralise a 20.00 mL sample of the diluted solution.

i. Calculate the number of mole of sodium hydroxide added.

(1 mark)

ii. Calculate the concentration of hydrochloric acid in the diluted solution.

(1 mark)

iii. Calculate the concentration of hydrochloric acid in the original cleaner.

(1 mark)

iv. What are two safety measures that users of this product should be advised to follow when using it?

(2 marks)

v. What dangerous goods label should be on the container?

(1 mark)

Question 2 (10 marks, 12 minutes)

a. When a piece of zinc metal is placed in an aqueous solution of lead(II) nitrate, a chemical reaction occurs.

i. Write an appropriate redox half-equation for the oxidation reaction.

(1 mark)

ii. Write an appropriate redox half-equation for the reduction reaction.

(1 mark)

iii. Write an appropriate chemical equation for the overall reaction.

(1 mark)

b. When a piece of sodium metal was carefully placed in a trough of cold water containing phenolphthalein solution, a violent chemical reaction occurred with a gas being evolved and the indicator changing colour.

i. What is the gas that is formed?

(1 mark)

ii. What would the indicator colour change indicate about the acid-base nature of the solution as a result of the reaction?

(1 mark)

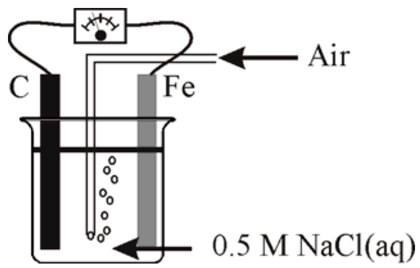
c. The apparatus shown in the diagram below was assembled to investigate the corrosion of iron. When completed, a small electric current was detected flowing through the external circuit.

On the diagram indicate the following:

i. The polarity of the electrodes.

ii. Which electrode is the anode and which is the cathode.

iii. The direction that the electrons will flow through the external circuit.



(3 marks)

d. In the apparatus in c. above, the carbon electrode was replaced with a zinc electrode.

i. What effect, if any, will this change have on the polarity of the electrodes and the direction of electron flow?

(1 mark)

ii. Give a reason for the answer given in d. i. above.

(1 mark)

Question 3 (10 marks, 12 minutes)

a. Aqueous solutions of hydrogen peroxide, H_2O_2, will decompose to form oxygen gas and water. Write an appropriate chemical equation for this reaction.

(1 mark)

b. The reaction in a. above is slow, however when a catalyst is added, oxygen gas is readily formed.
476 mL of dry oxygen gas at 22.6 °C and 99.9 kPa was produced when a 50.0 mL sample of an aqueous hydrogen peroxide solution decomposed in the presence of a catalyst.

i. Calculate the number of mole of oxygen gas formed.

(1 mark)

ii. Calculate the concentration of the hydrogen peroxide solution.

(2 marks)

c. The complete combustion of propane can be represented by the chemical equation;

$$C_3H_8(g) + 5O_2(g) \rightarrow 3CO_2(g) + 4H_2O(l)$$

A stoichiometric mixture of propane and oxygen was placed in a cylinder of fixed volume that was fitted with a spark plug. The initial pressure of the gases in the cylinder at 20 °C was 254 kPa. The gas mixture was ignited using the spark plug. What would be the gas pressure inside the cylinder when the temperature returned to 20 °C?

(1 mark)

d. An expandable helium balloon has a volume of 400 L when it was filled at 22 °C and 100.6 kPa. The balloon was released into the atmosphere and at a certain altitude the temperature and pressure were recorded as 4.18 kPa and -40 °C. What would be the volume of the balloon at this altitude?

(2 marks)

e. 1.00 g of liquid ethane, C_2H_6, has a volume of 1.83 mL.

i. Calculate the volume of 1.00 g of ethane gas at SLC.

(2 marks)

ii. Calculate the expansion ratio for ethane:
Volume occupied by 1 g of liquid: volume occupied by 1 g of gas.

(1 mark)

Question 4 (8 marks, 10 minutes)

The kinetic molecular theory model is very helpful in explaining the behaviour of gases.

a. What are two of the basic assumptions that the kinetic molecular theory model makes about gases?

(2 marks)

b. Use the kinetic molecular theory model to explain why gases are readily compressed.

(1 mark)

c. i. How is the pressure of a gas in a container explained using the kinetic molecular theory model?

(1 mark)

ii. Using the kinetic molecular theory model, explain why increasing the temperature of a gas sample in a container of fixed volume results in an increase in the pressure of the gas.

(1 mark)

iii. Using the kinetic molecular theory model, explain why the pressure of a gas sample decreases when the volume of the container is increased while keeping the temperature constant.

(1 mark)

d. A sample of gas in a cylinder contained helium and oxygen with volume percentages of 82.0 % and 18.0 % respectively. The pressure of the gas in the cylinder was 1200 kPa. What are the pressures due to each gas?

i. Helium:

(1 mark)

ii. Oxygen:

(1 mark)

Question 5 (6 marks, 7 minutes)

a. The amount of energy required to convert a liquid into a gas is known as the latent heat of vaporisation. The latent heat of vaporisation for methane and water, two molecular compounds with comparable molar masses, are 8 kJ mol^{-1} and 44 kJ mol^{-1} respectively. Explain why the latent heat of vaporisation for water is significantly higher than that for methane.

(2 marks)

b. The solubility of magnesium sulfate, $MgSO_4$, in water at 20 °C is 36.2 g $(100\ mL)^{-1}$. A 500.0 mL sample of an aqueous magnesium sulfate solution at 20 °C contained 159.5 g of magnesium sulfate.

i. Determine the concentration of the magnesium ions in this solution.

(3 marks)

ii. Determine if this solution is unsaturated, saturated or supersaturated.

(1 mark)

Question 6 (6 marks, 7 minutes)
The carbon-oxygen cycle helps explain how these elements move between the various spheres in the Earth's environment.

a. What are two processes that can remove carbon from the atmosphere?

(2 marks)

b. What are two processes, other than the combustion of fossil fuels, that can return carbon to the atmosphere?

(2 marks)

c. Other than global warming, what is one other effect that increased carbon dioxide emissions can have on the environment?

(1 mark)

d. What is one proposal that has been put forward for reducing the carbon dioxide emissions from fossil fuel fired power stations?

(1 mark)

End of Section B

End of Trial Exam

Suggested Answers

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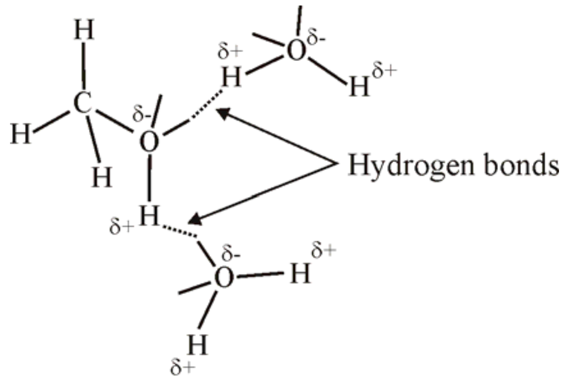
SECTION A – Multiple Choice Answers

(1 mark per question)

Q1 **C** When a carbonate reacts with an acid, **carbon dioxide gas and water are produced in addition to the 'salt'**. In the reaction between potassium carbonate and hydrochloric acid, the 'salt' will be potassium chloride. Potassium is in Group 1 of the Periodic Table, therefore all of its common ionic compounds are soluble in water. The reaction will therefore produce an aqueous solution of potassium chloride and can be described by the chemical equation.

$$K_2CO_3(s) + 2HCl(aq) \rightarrow 2KCl(aq) + CO_2(g) + H_2O(l)$$

Q2 **D** Methanol is a polar compound with a **polar hydroxy group**, -OH, and this group can readily **form hydrogen bonds with the polar water molecules**.



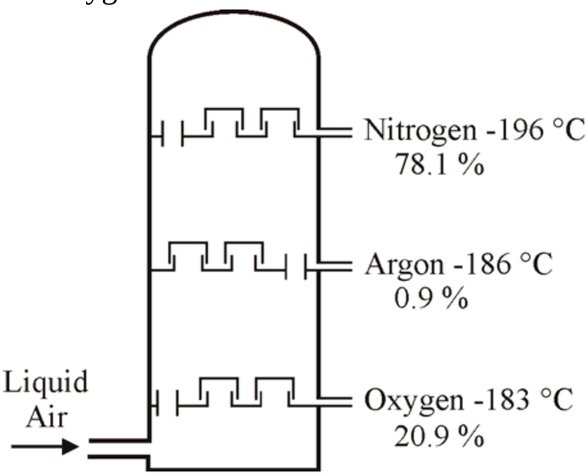
The hydrogen bond interactions are between the hydrogens covalently bonded to the oxygens and the non-bonding electron pairs on the oxygens.

The methyl, CH_3-, group is relatively small and does not contribute a sufficiently hydrophobic interaction with the water molecules, allowing the methanol molecules to be readily surrounded by the water.

In longer chain alkanols such as pentanol, the hydrophobic effect of the hydrocarbon chain has a much more significant contribution, thereby greatly reducing the solubility of the alkanol in water.

Q3 **B** Both gas samples are at SLC, therefore according to the kinetic molecular theory of gases, **the molecules of both gases will have the same average kinetic energy**. However **the mass of the ammonia molecules is lighter** than the hydrogen chloride molecules, **therefore they will have a higher average speed** and for a given time **diffuse further from their starting point**. The first solid formed on the tube will therefore be closer to the flask containing the hydrogen chloride gas. *The speed for the ammonia molecules is about 1.5 times that of the hydrogen chloride molecules.*
Position A is not correct because this would require the ammonia molecules to have significantly higher speeds, about eight times that of the hydrogen chloride molecules.

Q4 **A** The main components of dry air, in the lower atmosphere, are nitrogen and oxygen gases, making up 78.1 % and 20.9 % by volume respectively. The boiling temperatures for nitrogen and oxygen are -196 °C and -183 °C respectively, so they can be separated by **fractional distillation of liquid air**.
Air is liquefied by compression and expansion. The liquid is then allowed to evaporate at the bottom of a fractionating tower, which has trays at different temperatures with the lowest temperatures higher up the column. The nitrogen which has the lower boiling point will evaporate before the oxygen and travel higher up in the fractionating tower.



Q5 **C** **Calcium hydroxide will ionise** in aqueous solution

$Ca(OH)_2(aq) \rightarrow Ca^{2+}(aq) + 2OH^-(aq)$

$n(Ca(OH)_2) = c \times V = 0.0100 \times (50.00/1000) = 5.00\times10^{-4}$ mol
$n(OH^-) = 2n(Ca(OH)_2) = 2 \times 5.00\times10^{-4} = 1.00\times10^{-3}$ mol
V(Total) = 50.00 + 950.0 = 1000.0 mL = 1.00 L
$[OH^-] = n / V = 1.00\times10^{-3} / 1.00 = 1.00\times10^{-3}$ M
The self ionisation constant for water: $K_w = [H_3O^+][OH^-] = 1.00\times10^{-14}$ M^2
$[H_3O^+] = K_w / [OH^-] = 1.00\times10^{-14} / 1.00\times10^{-3} = 1.00\times10^{-11}$ M
$pH = -\log_{10}[H_3O^+] = -\log_{10}(1.00\times10^{-11}) =$ **11.0**

Q6 **B** The sample temperature is constant, therefore this is an application of Boyle's Law.
Boyle's Law states that the **volume of a gas sample at constant temperature is inversely proportional to the pressure** applied to the gas sample. This is usually written as the expression
PV = constant or $P_1V_1 = P_2V_2$
Therefore if the volume of the sample is halved by pushing the piston down, the pressure of the gas must increase to double its original pressure.
Originally: $P = P_1$ and $V = V_1$
On compression $V = ½V_1$
Therefore: $\mathbf{P_2} = P_1V_1/(½V_1) = \mathbf{2P_1}$

Q7 **D** A saturated solution of potassium chloride at 50 °C contains 42.80 g of solute in 100 mL of water. This therefore requires that the minimum mass of solute in the sample be:

m(KCl, 50 °C) = 42.80 × (500.0/100.0) = 214.0 g

The saturated solution at 25 °C contains 36.10 g of solute in 100 mL of water. Therefore this solution contains:

m(KCl, 25 °C) = 36.10 × (500/100) =180.5 g.

Therefore the minimum mass of potassium chloride required to ensure the solution is saturated at 50 °C is:

m(KCl, required) = 214.0 - 180.5 = 33.5 g.

Q8 **B** **Ultraviolet and visible light pass through the Earth's atmosphere** and strike the surface where some of the energy is absorbed and **lower energy infrared radiation is reflected back into space**. The greenhouse effect is due to **gases such as carbon dioxide, methane and water vapour absorbing infrared radiation that is reflected from the Earth's surface**. The increased amounts of gases such as carbon dioxide and methane due to human activities give rise to more infrared radiation being absorbed, thereby **increasing the temperature of the atmosphere and warming the Earth**. This is the enhanced greenhouse effect.

Q9 **D** **Nitrous acid, HNO_2(aq), is a weak acid**, therefore only a **small percentage of the acid will ionise** in water according to the chemical equation

$$HNO_2(g) + H_2O(l) \rightleftharpoons NO_2^-(aq) + H_3O^+(aq)$$

Four species are listed in the concentration lists, HNO_2(aq), H_3O^+(aq), NO_2^-(aq) and OH^-(aq).

In a **dilute aqueous solution of a weak acid**, the **concentration of the water is much greater than that of any of the other species**, and is essentially constant at 55.6 M.

Therefore for the species listed, the **concentration of the acid, HNO_2(aq), will be the largest as only a small percentage has ionised**.

Since the ionisation reaction yields the **same number of mole of hydrogen, H_3O^+(aq), and nitrite, NO_2^-(aq) ions**, therefore the concentrations of these two species will be equal.

The solution is an **acid**, therefore the concentration of hydroxide, **OH^-(aq), from the self ionisation of water will be the lowest**.

In this solution $[H_3O^+] = [NO_2^-] = 1.9\times10^{-2}$ M and $[OH^-] = 5.4\times10^{-13}$ M, therefore the $[HNO_2] = 0.48$ M.

Q10 **A** The water contains finely divided solid particles. The most appropriate treatment is **flocculation,** whereby chemicals are added, most commonly lime, $Ca(OH)_2$, and alum, $KAl(SO_4)_2$, that lead to the **particles clumping together and precipitating from the water**. The precipitate can be allowed to settle, thereby removing the particles from the supply.

Q11 **C** The reaction is: $2HgO(s) \rightarrow 2Hg(l) + O_2(g)$

The decrease in the mass of the sample after it has been heated is due to the formation of oxygen gas. Therefore the mass decrease is equal to the mass of oxygen gas.
$m(O_2) = 3.156$ g
$M(O_2) = 2\times16.0 = 32.0$ g mol^{-1}
$n(O_2) = m / M = 3.156 / 32.0 = 9.86\times10^{-2}$ mol
$n(HgO) = 2n(O_2) = 2 \times 9.86\times10^{-2} = 1.97\times10^{-1}$ mol
$M(HgO) = 200.6 + 16.0 = 216.6$ g mol^{-1}
$m(HgO) = 1.97\times10^{-1} \times 216.6 = 42.7$ g

Q12 **B** All of the gases are at SLC (Standard Laboratory Conditions)
The molar volume, V_m, of an ideal gas at SLC is 24.5 L mol^{-1}
$n(N_2) = V / V_m = 1.47 / 24.5 = 6.00\times10^{-2}$ mol
Response A: $n(H_2) = m / M = 0.060 / 2.0 = 3.00\times10^{-2}$ mol
Response B: **$n(Xe) = N / N_A = 3.61\times10^{22} / 6.02\times10^{23} = 6.00\times10^{-2}$ mol**
Response C: $n(O_3) = m / M = 1.92 / 48.0 = 4.00\times10^{-2}$ mol
Response D: $n(O_2) = N / N_A = 1.80\times10^{22} / 6.02\times10^{23} = 3.00\times10^{-2}$ mol

Q13 **A** The conditions are not standard therefore the general gas equation is required.
$PV = nRT$
$V = 750.0$ mL $= 0.750$ L

$$n = \frac{PV}{RT} = \frac{102.52 \times 0.750}{8.31 \times 298} = 3.10\times10^{-2} \text{ mol}$$

$M = m / n = 0.995 / 3.10\times10^{-2} =$ **32.0 g mol^{-1}**
Of the gases listed only O_2 fulfils this criterion.

Q14 **C** A precipitate has formed, therefore the compound needs to be either an insoluble barium or chloride compound.
Of the anions provided by the solutions, only the sulfate ion will form an insoluble barium compound, $BaSO_4$.

$$BaCl_2(aq) + (NH_4)_2SO_4(aq) \rightarrow BaSO_4(s) + 2NH_4Cl(aq)$$

$$Ba^{2+}(aq) + SO_4^{2-}(aq) \rightarrow BaSO_4(s)$$

All common lithium, potassium and ammonium compounds are soluble, and copper(II) chloride is also soluble.

Q15 **B** The chemical equation for the reaction:

$$2NH_3(aq) + H_2SO_4(aq) \rightarrow (NH_4)_2SO_4(aq)$$

$n(H_2SO_4) = c \times V = 0.130 \times (16.44/1000) = 2.14\times10^{-3}$ mol
From the chemical equation
$n(NH_3) = 2n(H_2SO_4) = 2 \times 2.14\times10^{-3} = 4.28\times10^{-3}$ mol
$c(NH_3) = n / V = 4.28\times10^{-3} / (20.00/1000) =$ **0.214 M**

Q16 **B** The **lower pH of the rain water causes magnesium ions, Mg^{2+}, to be leached from the soil**. **Magnesium is essential for photosynthesis** in plants as it is **required to form chlorophyll**. Therefore stunted plant growth occurs in areas where there is acid rain.

Nitrate ions can provide plants with nitrogen and act as fertilisers. Decreasing the pH generally results in the formation of more soluble phosphate containing compounds.

Q17 **B** Since the temperature and pressure are the same at SLC then the number of mole of the gases is directly proportional to the volumes of the gases, therefore the volume ratio can be used in the calculations.

$$2C_3H_6(g) + 9O_2(g) \rightarrow 6CO_2(g) + 6H_2O(l)$$

The mole ratio from the equation is 2 : 9.
$n(O_2) = {}^9/_2\ n(C_3H_6)$, therefore
$V(O_2) = {}^9/_2\ V(C_3H_6) = {}^9/_2\ (3.70) =$ **16.7 L**

Q18 **D** The oxidant in wet corrosion is **oxygen**, therefore it will be reduced and the iron oxidised, initially to iron(II) ions which will subsequently be further oxidised to iron(III) ions. The reactions can be represented by the following half-equations:
Reduction half-reaction:

$$O_2(aq) + H_2O(l) + 4e^- \rightarrow 4OH^-(aq)$$

Initial oxidation half-reaction:

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

This reaction is followed by a precipitation reaction where iron(II) hydroxide is formed:

$$Fe^{2+}(aq) + 2OH^-(aq) \rightarrow Fe(OH)_2(s)$$

The iron(II) hydroxide is then oxidised to iron(III) hydroxide.

$$4Fe(OH)_2(s) + O_2(aq) + 2H_2O(l) \rightarrow 4Fe(OH)_3(s)$$

Q19 **C** Photochemical smog, the brown haze often seen over cities, requires still atmospheric conditions to reduce the dilution of the reactants emitted by various sources and sunlight.

Q20 **B** The reaction between magnesium and aqueous sulfuric acid can be described by the ionic equation

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

Since the conditions are neither STP or SLC then the general gas equation must be used.
PV = nRT
T = 273 + 22.8 = 295.8 K
V = 956 mL = 956/1000 = 0.956 L

$$n(H_2) = \frac{PV}{RT} = \frac{110.0 \times 0.956}{8.31 \times 295.8} = 4.28 \times 10^{-2}\ \text{mol}$$

$n(Mg) = n(H_2) = 4.28 \times 10^{-2}$ mol
$m(Mg) = n \times M = 4.28 \times 10^{-2} \times 24.3 =$ **1.04 g**

Q21 A Nitrogen is essential for the formation of proteins required by both animals and plants. Nitrogen is abundant in the atmosphere but is only present in limited quantities in the soil, so must be fixed so that it can be useful. All **four alternatives provide fixation processes**; however the one that would **contribute least is lightning**, as only small amounts of nitrogen are fixed in this process. During lightning events, which are high energy events, nitrogen can react with oxygen to form various nitrogen oxides that will dissolve in rain. The nitrate, NO_3^-, and nitrite, NO_2^-, ions formed can be absorbed directly by plants or converted by bacteria in the soil, making the nitrogen available to plants and subsequently to animals that eat the plants.

Q22 C **Maximising the atom economy for the reactions** involved is **one of the twelve principles of green chemistry**. This ensures that there are fewer by-products from the process thereby reducing any waste formed.

Q23 D The water is acting as the oxidant and in a redox reaction the oxidant accepts electrons and is itself reduced. The redox half-equations for the reaction are:

Reduction reaction: $2H_2O(l) + 2e^- \rightarrow 2OH^-(aq) + H_2(g)$

Oxidation reaction: $Mg(s) \rightarrow Mg^{2+}(aq) + 2e^-$

These half-reactions are followed by a precipitation reaction of the insoluble magnesium hydroxide.

Precipitation reaction: $Mg^{2+}(aq) + 2OH^-(aq) \rightarrow Mg(OH)_2(s)$

Q24 C In the stratosphere, 12 – 25 km altitude, chlorofluorocarbons, CFC's, and halons can be photochemically broken down by the ultraviolet light to form chlorine atoms. These chlorine atoms can then react with ozone. This reaction competes with the reaction that occurs when ozone is photochemically decomposed as it protects the Earth's surface from ultraviolet radiation.
The ozone in the stratosphere absorbs the harmful ultraviolet radiation coming from the Sun and in doing so is decomposed to form oxygen molecules, O_2, and an oxygen atom, O•. Oxygen molecules are also photochemically decomposed to oxygen atoms. However ozone will reform when oxygen molecules and oxygen atoms react. These reactions can be represented by the chemical equations;

$O_3(g) \xrightarrow{UV} O_2(g) + O\bullet(g)$

$O_2(g) \xrightarrow{UV} 2O\bullet(g)$

$O_2(g) + O\bullet(g) \rightarrow O_3(g)$

A CFC such as trichlorofluoromethane, CCl_3F, will react as described by the following chemical equations;

$CCl_3F(g) \xrightarrow{UV} \bullet CCl_2F(g) + Cl\bullet(g)$

$Cl\bullet(g) + O_3(g) \rightarrow ClO(g) + O_2(g)$

$ClO(g) + O(g) \rightarrow Cl\bullet(g) + O_2(g)$

Therefore because of the competition of these reactions, the amount of ozone in the stratosphere decreases.
Nitrogen oxides in the stratosphere can also cause ozone depletion, but those released by cars and trucks have little impact at this altitude. The increased use of fossil fuels and methane released from agriculture are both greenhouse gases and these have not been shown to impact on stratospheric ozone levels.

SECTION B – Short Answer (Answers)

Question 1 (12 marks, 14 minutes)

a. An amphiprotic substance can act as either an acid or a base. As an acid it will be a proton donor and as a base it will be a proton acceptor. The formula for the hydrogen carbonate ion is HCO_3^-.

Acting as an acid:

$HCO_3^-(aq) + H_2O(l) \rightarrow CO_3^{2-}(aq) + H_3O^+(aq)$ **(1 mark)**.

Acting as a base:

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

An alternative would be:

$HCO_3^-(aq) + H_3O^+(aq) \rightarrow H_2CO_3(aq) + H_2O(l)$

b. A conjugate acid for a species has an additional H^+ in its formula. Therefore the conjugate acid for the amide ion, NH_2^-, would be **NH_3 (1 mark)**.

c. i. Hydrochloric acid, HCl, is a strong acid so it will completely ionise in water as described by the chemical equation

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

c(HCl) = 0.050 M

$[H_3O^+]$ = 0.050 M

pH = $-\log_{10}[H_3O^+] = -\log_{10}(0.050)$ = **1.3 (1 mark)**.

ii. The pH of an 0.20 M acid solution is 2.79. This implies that

$[H_3O^+] = 10^{-pH} = 10^{-2.79} = 1.6\times10^{-3}$ M

Since the **$[H_3O^+]$ is much less than that of the propanoic acid,** it implies that propanoic acid is a **weak acid (1 mark)**.

d. Nitric acid: HNO_3

Manganese(IV) oxide: MnO_2

When an oxide reacts with water it produces water and a 'salt'.

A full or ionic equation would be appropriate **(1 mark)**.

Full equation: $MnO_2(s) + 4HNO_3(aq) \rightarrow Mn(NO_3)_4(aq) + 2H_2O(l)$

Ionic equation: $MnO_2(s) + 4H^+(aq) \rightarrow Mn^{4+}(aq) + 2H_2O(l)$

e. $HCl(aq) + NaOH(aq) \rightarrow NaCl(aq) + H_2O(l)$

i. n(NaOH) = c × V = 0.187 × (12.14/1000) = **2.27×10^{-3} mol (1 mark)**.

ii. For the diluted sample:

n(HCl) = n(NaOH) = 2.27×10^{-3} mol

c(HCl) = n / V = 2.27×10^{-3} / (20.00/1000) = **1.14×10^{-1} M (1 mark)**.

iii. The cleaner sample was diluted 5:500 or by 100 fold.

c(HCl, original) = 100 × 1.14×10^{-3} = 1.14×10^{1} M = **11.4 M (1 mark)**.

iv. Possible answers include:

[Total marks allocated = 2 marks, 1 mark for a correct answer]

Wear goggles or protective eye wear.

Wear rubber gloves.

Wear protective clothing.

Do not ingest.

Wash off skin immediately with copious amounts of water.

Dilute by adding acid to water.

v. The appropriate dangerous goods label would be that for a **corrosive substance (1 mark)**.

Question 2 (10 marks, 12 minutes)

a. Using the electrochemical series from the VCE Exam Data Booklet (Table 2), the oxidant and reductant can be identified as lead(II) ions and zinc metal respectively. **O**xidation **i**nvolves the **l**oss of electrons and **r**eduction **i**nvolves the **g**ain of electrons (OILRIG), and the oxidant will be reduced while the reductant is oxidised.

i. The oxidation half-equation:

$Zn(s) \rightarrow Zn^{2+}(aq) + 2e^{-}$ **(1 mark)**.

ii. The reduction half-equation:

$Pb^{2+}(aq) + 2e^{-} \rightarrow Pb(s)$ **(1 mark)**.

iii. The overall chemical equation for the reaction will be the sum of the two half equations when the number of electrons lost and gained is balanced. In this reaction both the reduction and oxidation half-reactions involve two electrons, therefore the overall chemical is the sum of the two half-equations.

$Zn(s) + Pb^{2+}(aq) \rightarrow Zn^{2+}(aq) + Pb(s)$ **(1 mark)**.

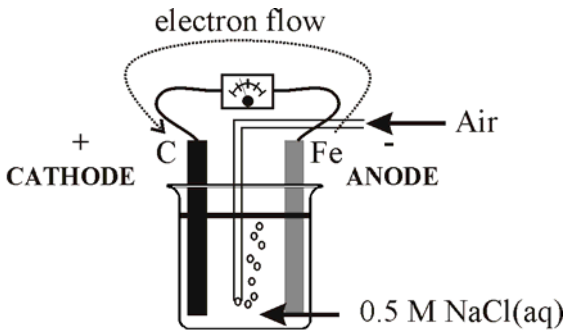
b. Using the electrochemical series, sodium can be identified as being a strong reductant and the oxidant in this reaction will be water.

i. The gas evolved will be **hydrogen, H_2(g) (1 mark)**.
The half-equation for the reduction reaction will be:

$2H_2O(l) + 2e^{-} \rightarrow H_2(g) + 2OH^{-}(aq)$

ii. The reduction half-reaction also results in the formation of **hydroxide, OH^{-}(aq)**, ions which are **basic**, therefore the indicator will change to its basic colour **(1 mark)**.

c. The carbon electrode is unreactive and its role is to facilitate the transfer of electrons. Using the electrochemical series, it can be determined that the reductant in this reaction will be the iron and the oxidant will be the oxygen from the air being bubbled through the solution.



i. Since the **iron is being oxidised**, the **iron electrode will have a negative charge**, while the carbon electrode will be positively charged **(1 mark)**.

ii. **Oxidation** always occurs **at the anode** (AN OILRIG CAT), therefore the **iron** will be the **anode**. **(1 mark)**.

iii. The **electrons flow from the anode to the cathode** through the external circuit **(1 mark)**.
The half-equations will be:

Iron electrode (anode): $Fe(s) \rightarrow Fe^{2+}(aq) + 2e^{-}$

Carbon electrode (cathode): $O_2(g) + 2H_2O(l) + 4e^{-} \rightarrow 4OH^{-}(aq)$

Overall Reaction: $2Fe(s) + O_2(g) + 2H_2O(l) \rightarrow 2Fe^{2+}(aq) + 4OH^{-}(aq)$

d. i. By referring to the electrochemical series (Table 2 VCE Chemistry Data Book), zinc is a stronger reductant than iron, therefore it will be oxidised in this cell. The **polarity of the electrodes will change**, with the **iron** becoming the **positive** electrode while the **zinc** will become the **negative** electrode. The direction of the **electron flow will reverse**, **flowing from the zinc to the iron (1 mark)**.

ii. When the carbon electrode is replaced with a zinc electrode, the **zinc** metal is the **stronger reductant** than the iron and will therefore be **oxidised in preference**. Therefore the **zinc electrode will be the anode** and the iron will become the cathode where the reduction reaction will occur **(1 mark)**.

The overall chemical equation will become:

$$2Zn(s) + O_2(g) + 2H_2O(l) \rightarrow 2Zn^{2+}(aq) + 4OH^-(aq)$$

This is an example of how sacrificial protection of iron can be achieved.

Question 3 (10 marks, 12 minutes)

a. The products of the decomposition of hydrogen peroxide are oxygen gas and water.

$2H_2O_2(aq) \rightarrow O_2(g) + 2H_2O(l)$ **(1 mark)**.

b. i. The conditions are neither STP nor SLC, therefore the general gas equation, PV = nRT, will need to be used.

P = 99.9 kPa

V = 476 mL = 476/1000 = 0.476 L

T = 22.6 °C = 273 + 22.6 = 295.6 K

$n(O_2) = \frac{PV}{RT} = \frac{99.9 \times 0.476}{8.31 \times 295.6}$ = **1.94×10^{-2} mol (1 mark)**.

ii. From the chemical equation the molar ratio of $O_2 : H_2O_2$ is 1 : 2

$n(H_2O_2) = 2n(O_2) = 2 \times 1.94 \times 10^{-2} = 3.88 \times 10^{-2}$ mol **(1 mark)**.

$c(H_2O_2) = n / V = 3.88 \times 10^{-2} / (50.00/1000)$ = **0.776 M (1 mark)**.

c. $C_3H_8(g) + 5O_2(g) \rightarrow 3CO_2(g) + 4H_2O(l)$

Since the temperature and volume of the reactants and products are the same then the pressure is directly proportional to the number of mole of substance.

The reaction mixture is in the correct stoichiometric mix, that is there are five mol of oxygen for each mol of propane.

From the chemical equation there are six mol of gaseous reactants, propane and oxygen together, and this produces three mol of gaseous products, carbon dioxide.

n(products) = $^3/_6$n(reactants) = $^1/_2$n(reactants)

P(products) = $^1/_2$P(reactants) = $^1/_2 \times 254$ = **127 kPa (1 mark)**.

d. The same gas is at two different sets of conditions, therefore the relationship to be used is

$$\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}$$

P_1 = 100.6 kPa | P_2 = 4.18 kPa

V_1 = 400 L | V_2 = ?

T_1 = 273 + 22 = 295 K | T_2 = 237 + (-40) = 233 K

$V_2 = \frac{P_1V_1T_2}{T_1P_2} = \frac{100.6 \times 400 \times 233}{295 \times 4.18}$ = **7600 L (2 marks)**.

e. i. $M(C_2H_6) = 2 \times 12.0 + 6 \times 1.0 = 30.0$ g mol^{-1}
$n(C_2H_6) = m / M = 1.00 / 30.0 = 3.33 \times 10^{-2}$ mol **(1 mark)**.
Since the conditions are at SLC then
$V(C_2H_6) = n \times V_m = 3.33 \times 10^{-2} \times 24.5 =$ **8.17×10^{-1} L (1 mark)**.

ii. V(liquid) = 1.83 mL
V(gas) = 8.17×10^{-1} L = 817 mL
V(liquid) : V(gas) = 1.83 : 817 = **1 : 446 (1 mark)**.

Question 4 (8 marks, 10 minutes)

a. The assumptions of the kinetic molecular theory model are listed below.
[Total marks allocated = 2 marks, 1 mark for a correct response]
Gases are made up of small particles, the total volume of which is significantly smaller than the volume that the gas occupies. Most of the volume that gases occupy is made up of empty space.
The particles move in straight lines and collide with each other and the walls of the containing vessel.
The forces between the particles are extremely weak, so that the particles can be assumed to move around on their own.
The collisions between the particles are elastic.
Kinetic energy can be transferred between particles during collisions.
The particles have a range of kinetic energies and the average kinetic energy will increase as the temperature of the gas is increased.

b. The kinetic molecular theory model assumes that **most of the volume occupied by a gas sample is empty space** therefore **when a gas is compressed,** the particles occupy less space and there is **less empty space (1 mark)**.

c. i. Pressure is a force on an area of surface. The pressure of a gas results from the **collision of the gas particles with the walls of the containing vessel (1 mark)**.

ii. When the **temperature of a gas sample is increased the average kinetic energy of the particles increases**. Since the average kinetic energy increases then the **average speed of the particles increases**, therefore there is a **higher chance of a collision between the particles and the walls of the containing vessel,** resulting in an **increase in pressure (1 mark)**.

iii. When the **volume of a vessel is increased,** the gas **particles have more space** in which to move, therefore there is a **lower chance of collisions between the particles and the walls of the containing vessel** and as a result the **pressure decreases (1 mark)**.

d. The kinetic molecular theory model assumes the pressure is due to the sum of the individual gas pressures. The individual gas pressures will depend on the amount of each gas present. For a given temperature, the amount of a gas will be proportional to its percentage by volume.

i. $P(He) = \%(He) \times P_{Total} = (82.0/100) \times 1200 =$ **984 kPa (1 mark)**.

ii. $P(O_2) = \%(O_2) \times P_{Total} = (18.0/100) \times 1200 =$ **216 kPa (1 mark)**.

Question 5 (6 marks, 7 minutes)

a. When a **liquid boils,** the **bonds between the particles** that make up the liquid **have to be broken**. In liquid **water** there are **hydrogen bonds, dipole-dipole interactions and dispersion forces between the water molecules**, whereas in liquid **methane** there are only the **weaker dispersion forces between the methane molecules (1 mark).** Because there are **stronger interactions between the water molecules more energy will be required to separate the water molecules from one another.** Therefore the latent heat of vaporisation for water is significantly higher than that for methane because **there are much stronger interactions between the water molecules than the methane molecules**. **(1 mark)**

b. i. $M(MgSO_4) = 24.3 + 32.1 + 4\times16.0 = 120.4\ g\ mol^{-1}$

$n(MgSO_4) = m / M = 159.5 / 120.4 = 1.325$ mol **(1 mark)**.

$c(MgSO_4) = n / V = 1.325 / (500.0/1000) = 2.650$ M **(1 mark)**.

Since each $MgSO_4$ contains one Mg^{2+} ion then

$$MgSO_4(aq) \rightarrow Mg^{2+}(aq) + SO_4^{2-}(aq)$$

$c(Mg^{2+}) = c(MgSO_4) =$ **2.650 M (1 mark)**.

ii. The solution contains 159.5 g of $MgSO_4$ in 500.0 mL, therefore in 100 mL

$m(MgSO_4$, in 100 mL$) = 159.5 / (500.0/100) = 31.9$ g $(100\ mL)^{-1}$

The solubility at 20 °C is 36.2 g $(100\ mL)^{-1}$

Since the solubility is greater than the amount of solid dissolved then the solution is **unsaturated (1 mark)**.

Question 6 (6 marks, 7 minutes)

a. Possible answers: **[1 mark each. Total marks allocated = 2 marks]**

Photosynthesis – where plants convert carbon dioxide and water into glucose and oxygen.

$$6CO_2(g) + 6H_2O(l) \rightarrow C_6H_{12}O_6(aq) + 6O_2(g)$$

Carbon dioxide dissolving in the oceans – this is the second highest contributor to the removal of CO_2 after photosynthesis, however increased levels of dissolved CO_2 can result in the acidification of the oceans and detrimental effects on marine life.

$$CO_2(g) \rightleftharpoons CO_2(aq)$$

The formation of limestone, $CaCO_3$, from marine animal skeletons.

b. Possible answers: **[1 mark each. Total marks allocated = 2 marks]**

Respiration – where animals and plants convert glucose and oxygen into carbon dioxide and water to provide energy.

$$C_6H_{12}O_6(aq) + 6O_2(g) \rightarrow 6CO_2(g) + 6H_2O(l)$$

The **decay of animal and plant materials –** this can lead to the formation of carbon dioxide and methane

Volcanoes – emit carbon dioxide among other gases.

The **combustion of plant materials –** such as the burning of wood.

Deforestation – often involves the burning of the plant materials cut down but other processes in the soil lead to the increased emission of carbon based compounds into the atmosphere.

Cement production – this industrial process involves the conversion of calcium carbonate into calcium oxide.

$$CaCO_3(g) \rightarrow CaO(s) + CO_2(g)$$

Combustion of biofuels – any carbon containing compound will produce CO_2 when it is completely burnt. For example ethanol, C_2H_5OH;

$$C_2H_5OH(l) + 3O_2(g) \rightarrow 2CO_2(g) + 3H_2O(l)$$

c. **Carbon dioxide is an acidic oxide** and when it is dissolved in water, forms the weak acid, **carbonic acid, H_2CO_3**. This can lead to an increased acidity of rain and when dissolved in the oceans, have adverse effects on the skeletal development of marine creatures such as corals **(1 mark)**.

$$CO_2(aq) + H_2O(l) \rightleftharpoons H_2CO_3(aq)$$

$$H_2CO_3(aq) + H_2O(l) \rightleftharpoons HCO_3^-(aq) + H_3O^+(aq)$$

d. **Carbon capture** is a method that has been proposed for reducing the carbon dioxide emission from fossil fuel fire power stations. **(1 mark)** In this process the carbon dioxide gas is removed from the flue gases and either stored by a variety of processes, including injection into depleted natural gas wells (referred to as sequestration), or converted into other chemicals.

End of Suggested Answers