Neap:

Trial Examination 2013

VCE Chemistry Unit 2

Written Examination

Question and Answer Booklet

Reading time: 15 minutes
Writing time: 1 hour 30 minutes

Student's Name: _____

Teacher's Name: _____

Structure of Booklet

Section	Number of questions	Number of questions to be answered	Marks
A Multiple-choice	20	20	20
B Short-answer	4	4	55
			Total 75

Students are permitted to bring into the examination room: pens, pencils, highlighters, erasers, sharpeners, rulers and one scientific calculator.
Students are NOT permitted to bring into the examination room: blank sheets of paper and/or white out liquid/tape.

Materials supplied

Question and answer booklet of 15 pages, with a detachable data booklet in the centrefold.
Answer sheet for multiple-choice questions.

Instructions

Detach the data booklet from the centre of this booklet during reading time.
Please ensure that you write **your name** and your **teacher's name** in the space provided on this booklet and in the space provided on the answer sheet for multiple-choice questions.
All written responses must be in English.

At the end of the examination

Place the answer sheet for multiple-choice questions inside the front cover of this booklet and hand them in.

Students are NOT permitted to bring mobile phones and/or any other unauthorised electronic devices into the examination room.

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SECTION A: MULTIPLE-CHOICE QUESTIONS

Instructions for Section A

Answer **all** questions in pencil on the answer sheet provided for multiple-choice questions.

Choose the response that is **correct** or that **best answers** the question.

A correct answer scores 1, an incorrect answer scores 0.

Marks will **not** be deducted for incorrect answers.

No marks will be given if more than one answer is completed for any question.

Question 1

Water is able to act as an oxidant, a reductant, an acid and a base.

Which of the following shows the conjugate oxidant and conjugate base of the water molecule?

	Conjugate oxidant	**Conjugate base**
A.	O_2	OH^-
B.	O_2	H_3O^+
C.	H_2	OH^-
D.	H_2	H_3O^+

Question 2

A cylinder fitted with a sliding piston contains 10 L of gas at 40°C.

If the temperature is lowered to 20°C whilst the pressure remains constant, the final volume of the gas (in litres) is

A. 4.7
B. 5.0
C. 9.4
D. 20

Question 3

A student is given pure samples of carbon dioxide, nitrogen and oxygen gases in separate unlabelled test tubes. Each tube contains only one of the gases.

Which of the following tests alone would determine which test tube contains carbon dioxide gas?

A. Add water to each test tube and test the pH of the resulting solution.
B. Compare the amount in mole of each gas found in equal volumes at the same temperature and pressure.
C. Insert a glowing splint into each gas.
D. Note the colour of each gas.

Question 4

Which one of the following is a feature of distillation used to desalinate saltwater?

A. An inexpensive, energy efficient process involving a number of chemical reactions.
B. A chemical reaction in the saltwater produces two changes of state during the desalination.
C. The total number of mole of ions in the saltwater increases as the process continues.
D. Energy is used in one change of state, and is released in the other change of state.

Question 5

The results of various experiments to determine the reactivity of metals X, Y and Z are shown in the table.

Experiment	Observations
1. Metals placed separately in dilute HCl	only X and Y cause hydrogen gas release
2. Y placed in solution of Z^{2+} ions	metal Z is formed
3. X placed in solution of Y^{2+} ions	no reaction

Commencing with the least reactive, the reactivity order of the metals is

A. Y < X < Z
B. X < Z < Y
C. Z < X < Y
D. Y < Z < X

Question 6

0.30 mol of magnesium is added to a solution containing 0.50 mol of HCl.

When the reaction is complete there will be

A. 0.30 mol of H_2 gas produced.
B. 0.050 mol of Mg unreacted.
C. 0.20 mol of HCl unreacted.
D. 0.25 mol of Cl^- ions in the solution.

Question 7

Which of the following statements about pure water are correct?

I At any temperature $[H_3O^+] = [OH^-]$.
II The pH could be less than 7 but the water is still neutral.
III If the $[H_3O^+] < 10^{-7}$ M, the water must be alkaline.

A. I and II only
B. II and III only
C. I and III only
D. I, II and III

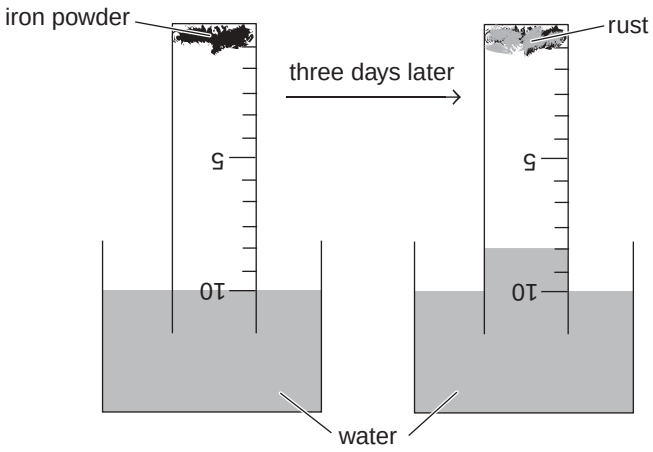
Question 8

When 50.0 mL of 0.100 M of the strong acid HA is added to 100.0 mL of water, the pH of the diluted solution is closest to

A. 1.0
B. 1.3
C. 1.5
D. 2.3

Use the following information to answer Questions 9 and 10.

The diagram below shows an experiment conducted to investigate the rusting of iron.



Question 9

One of the reactions which occurs as the experiment proceeds is shown by the following equation:

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

The reduction half-equation for this reaction can be represented by

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

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

C. $4OH^-(aq) \rightarrow O_2(g) + 2H_2O(l) + 4e^-$

D. $O_2(g) + 2H_2O(l) + 4e^- \rightarrow 4OH^-(aq)$

Question 10

Which of these statements about the composition of air would be supported by the results of the experiment?

I Approximately $\frac{4}{5}$ of air is nitrogen gas.

II Oxygen comprises about 20% of air by volume.

III The percentage of water vapour in air is very small.

A. I only

B. II only

C. I and II only

D. I, II and III

Question 11

In the treatment of water to make it suitable for drinking, solid $Ca(OH)_2$ and $Al_2(SO_4)_3$ are often added.

Which one of the following statements concerning this treatment is **incorrect**?

A. $Ca(OH)_2$ can neutralise water when it has a pH which is less than 7.

B. The hydroxide ions needed for flocculation may be provided by $Ca(OH)_2$.

C. Addition of $Al_2(SO_4)_3$ allows the formation of $Al(OH)_3$ gel which traps fine particles in the water.

D. Both $Ca(OH)_2$ and $Al_2(SO_4)_3$ are added to kill bacteria and other microbes in the water.

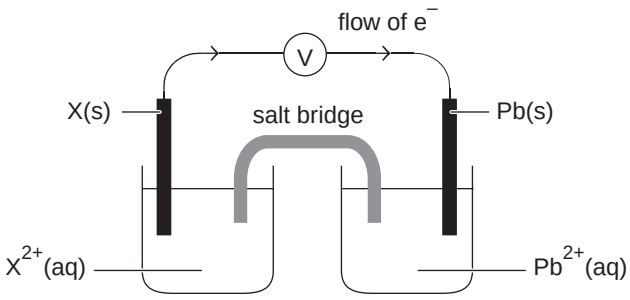
Question 12

When ethanol (C_2H_5OH) is dissolved in water, which of these interactions are present between atoms?

A. covalent bonds and dispersion forces only
B. hydrogen bonding and covalent bonds only
C. dispersion forces and hydrogen bonding only
D. covalent bonds, dispersion forces and hydrogen bonding

Use the following information to answer Questions 13–15.

The galvanic cell below is formed by the combination of two half-cells: $X^{2+}(aq)/X(s)$ and $Pb^{+}(aq)/Pb(s)$. When the cell is operating, the electron flow is as shown.



Question 13

Which of the following correctly identifies the nature of the electrode and the reaction occurring at the lead electrode?

A. Pb is the anode, and the reaction occurring is $Pb^{2+}(aq) + 2e^{-} \rightarrow Pb(s)$.
B. Pb is the cathode, and the reaction occurring is $Pb^{2+}(aq) + 2e^{-} \rightarrow Pb(s)$.
C. Pb is the anode, and the reaction occurring is $Pb(s) \rightarrow Pb^{2+}(aq) + 2e^{-}$.
D. Pb is the cathode, and the reaction occurring is $Pb(s) \rightarrow Pb^{2+}(aq) + 2e^{-}$.

Question 14

Based on the observations of the galvanic cell, which of the following metals could X be?

A. aluminium
B. silver
C. copper
D. nickel

Question 15

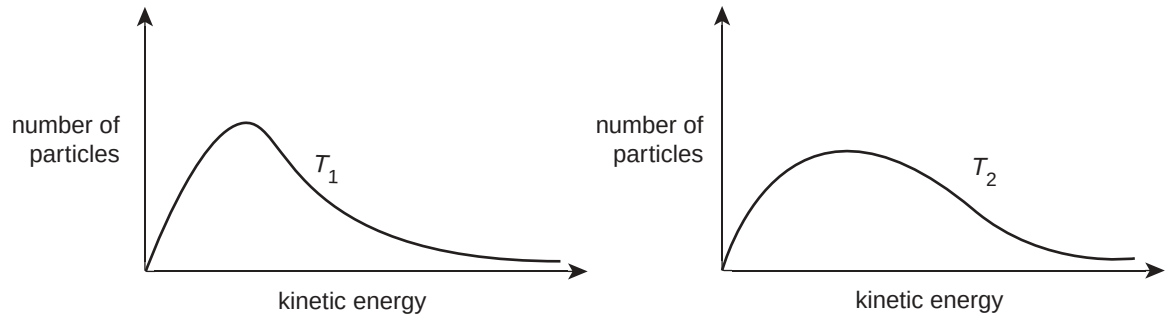
The lead(II) and X(II) solutions are both prepared using nitrate salts. The salt bridge contains potassium nitrate solution.

After the cell has been operating for some time, the nitrate ion concentration would be expected to be

A. highest in the beaker containing metal X.
B. highest in the beaker containing Pb.
C. highest in the salt bridge.
D. the same in both beakers and the salt bridge.

Question 16

The diagrams show the distribution of the kinetic energy of molecules in a gas sample under identical conditions but at two different temperatures, T_1 and T_2.



Which of the following statements are correct?

I The average kinetic energy of molecules is greater at T_1 than T_2.

II The proportion of molecules with high kinetic energy decreases with increasing temperature.

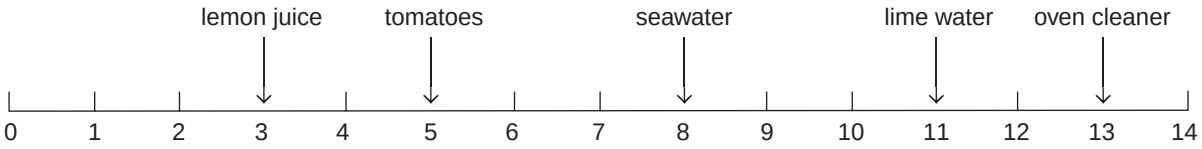
III The average speed of molecules is greater at T_2 than T_1.

IV At any temperature, most molecules do not have very high or very low speeds.

A. I and II only
B. I and III only
C. III and IV only
D. II, III and IV only

Question 17

The diagram shows the pH of a range of substances at 25°C.



Which of these statements is **incorrect**?

A. Diluting lime water by a factor of 100 would give the same pH as the over cleaner.

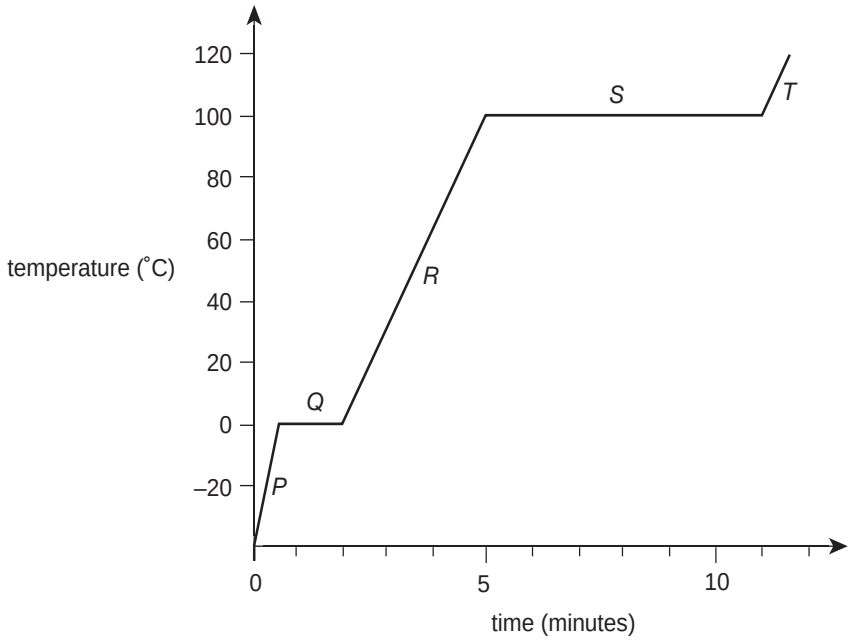
B. The concentration of hydroxide ions in the oven cleaner is 0.1 M.

C. $[H_3O^+]$ in tomatoes is much lower than its concentration in lemon juice.

D. $[H_3O^+]$ in lemon juice is equal to $[OH^-]$ in limewater.

Use the following information to answer Questions 18 and 19.

The graph below displays the data recorded when an ice sample in a beaker was heated constantly over time and the temperature of the beaker's contents was recorded each minute. Individual sections of the graph have been labelled with the letters *P* to *T*.



Question 18

In which sections of the graph would ice be present in the beaker?

A. *P* only
B. *P* and *Q* only
C. *Q* and *R* only
D. *P, Q* and *R* only

Question 19

Which sections of the graph illustrate that water has high latent heat values?

A. *P* and R
B. *Q* and *S*
C. *R* and *T*
D. *Q, R* and *S*

Question 20

When 3.0 mol of propane and 4.0 mol of oxygen were placed in an empty 50 L vessel, the total pressure was 100 kPa. The mixture was ignited to initiate the following reaction:

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

The total pressure of the vessel, in kPa, after the reaction was completed and the contents were allowed to return to the original temperature is closest to

A. 86
B. 100
C. 111
D. 234

SECTION B: SHORT-ANSWER QUESTIONS

Instructions for Section B

Answer **all** questions in the spaces provided.

To obtain full marks for your responses you should

- give simplified answers with an appropriate number of significant figures to all numerical questions; unsimplified answers will not be given full marks.
- show all working in your answers to numerical questions. No credit will be given for an incorrect answer unless it is accompanied by details of the working.
- make sure chemical equations are balanced and that the formulas for individual substances include an indication of state, for example $H_2(g)$; NaCl(s).

Question 1 (13 marks)

The method below may be used for the preparation of copper(II) ethanoate, a salt of ethanoic acid (CH_3COOH).

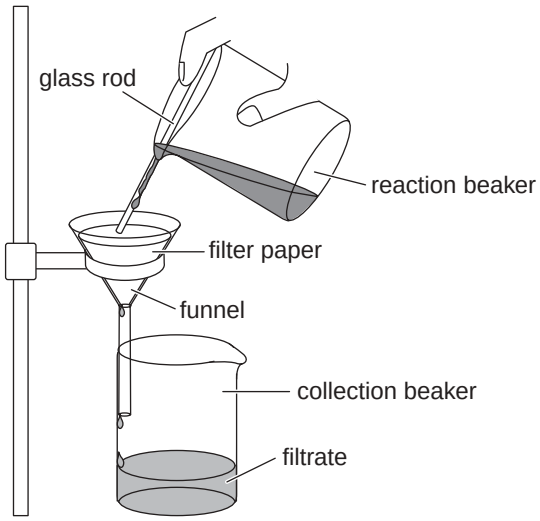
Step 1: 50.0 mL of 0.50 M ethanoic acid was placed in a beaker.

Step 2: 0.50 g quantities of copper(II) carbonate ($CuCO_3$) powder were added progressively to the acid solution with stirring. Gas bubbles evolved.

Step 3: After a total mass of 3.50 g of $CuCO_3$ was added, no further bubbles were observed.

Step 4: The contents of the reaction beaker was filtered as shown in the diagram.

Step 5: Solid copper(II) ethanoate was then isolated and weighed.



a. Ethanoic acid is a weak, monoprotic acid. Explain the meaning of the terms

i. weak 1 mark

_____

_____

ii. monoprotic 1 mark

_____

_____

b. Write a balanced chemical equation for the chemical reaction which occurred. 2 marks

_____

c. How could the solid copper(II) ethanoate be isolated in **Step 5**? 1 mark

_____

_____

d. **i.** Calculate the number of mole of ethanoic acid dispensed into the beaker. 1 mark

_____

ii. Calculate the mass of copper(II) ethanoate formed in the chemical reaction, given that the molar mass of copper(II) ethanoate is 181.5 g mol^{-1}. 2 marks

_____

_____

e. The mass of solid copper(II) ethanoate isolated in **Step 5** is less than the mass calculated in **part d. ii**.

Suggest **one** reason why the collected mass is less than expected. 1 mark

_____

_____

f. Why was copper(II) carbonate powder added in **Step 3** until no further bubbles appeared? 1 mark

_____

_____

g. The experiment was repeated using 50.0 mL of 0.50 M hydrochloric acid.

i. Suggest **one** difference which would be observed in the experiment when HCl was used in place of CH_3COOH. 1 mark

_____

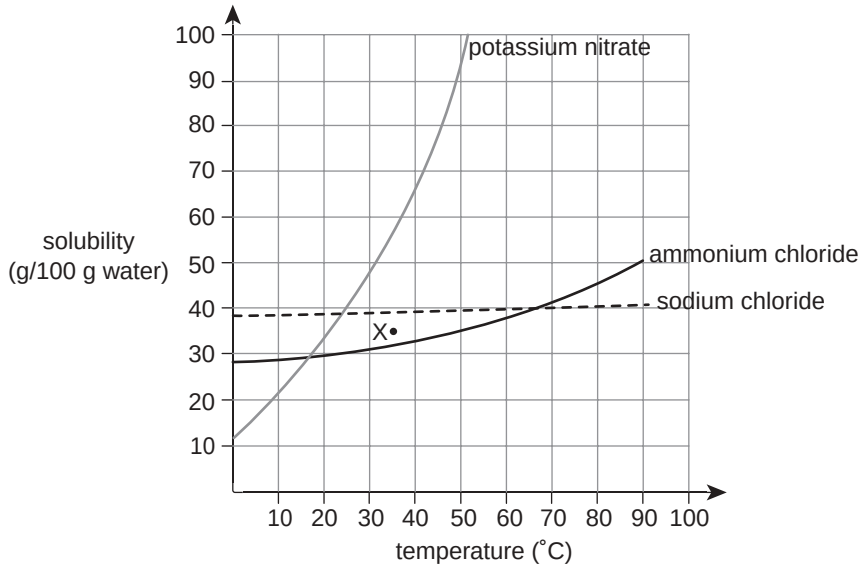
_____

ii. In the following table, tick the **two** correct statements when comparing 0.50 M hydrochloric acid and 0.50 M ethanoic acid. 2 marks

1. Both acids will conduct electricity but ethanoic acid will have greater conductivity.	
2. If equal volumes of each acid are neutralised using 0.10 M NaOH solution, hydrochloric acid will require more of the base.	
3. At 25°C, each acid has a different pH which is less that 7 but greater than 0.	
4. The number of uncharged solute particles will be identical in a set volume of each acid.	
5. Each acid will have the same effect on the colour of litmus paper, but not on the colour of universal indicator.	
6. In the same volume of each acid, the amount of water will differ by a very large number of moles.	

Question 2 (18 marks)

Sodium chloride has a wide range of uses and is an important compound in industry. The solubility curve of sodium chloride and two other compounds is shown below.



a. **i.** At point X, which of the solutions could be described as unsaturated? 1 mark

_____

ii. 10 g of potassium nitrate is dissolved in 30 g of water at 50°C. The solution is then cooled to 10°C without forming a supersaturated solution.

Calculate the mass of potassium nitrate, in grams, which would crystallise out of solution. 2 marks

_____

_____

_____

iii. Calculate the number of potassium ions in a saturated solution of KNO_3 at 40°C which is made by dissolving the solute in 100 g of water. 2 marks

_____

_____

_____

_____

b. A solution consists of 3.0 g of NaCl dissolved in water and made up to a total volume of 250.0 mL

Give the concentration of this solution in

i. mol L^{-1} 2 marks

_____

_____

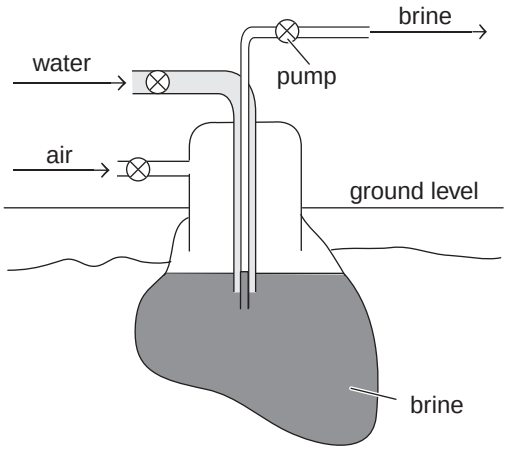
ii. % m/v 1 mark

_____

_____

c. Draw a labelled diagram to show how the sodium ion is present in water when sodium chloride dissolves in water. Label the bond types present. 2 marks

d. Solid sodium chloride is found in deposits well below ground level. The following diagram shows a method used to bring the sodium chloride to the surface as a concentrated aqueous solution known as brine. Cold water is usually used in this process.



i. Suggest **one** advantage of using hot water for the process. 1 mark

_____

ii. Suggest **one** reason why cold water is usually used rather than hot water. 1 mark

_____

_____

iii. The brine is treated with sodium hydroxide to remove any magnesium ion contamination by precipitation.

Write the ionic equation for this precipitation reaction. 1 mark

_____

e. Electricity is used to cause the following chemical reaction in the brine:

$$2NaCl(aq) + 2H_2O(l) \rightarrow 2NaOH(aq) + Cl_2(g) + H_2(g)$$

i. Name the chemical species acting as the reductant in this reaction. 1 mark

_____

ii. Write the half-equation for the oxidation process occurring in the reaction. 1 mark

_____

iii. Calculate the volume of hydrogen gas produced at SLC for each tonne (10^6 g) of sodium chloride used in the reaction. 3 marks

_____

_____

_____

_____

Question 3 (10 marks)

Although carbon dioxide comprises less than 1% of air, it has a significant influence on the quality of the atmosphere.

a. Outline one method of industrial preparation of carbon dioxide or one other gas which is present in the atmosphere. 2 marks

_____

_____

_____

b. When carbon dioxide gas is dissolved in water, the hydrogen carbonate ion (HCO_3^-) is formed.

i. HCO_3^- can act as an acid or a base.

What term is used for this property? 1 mark

_____

ii. Explain, with the aid of an equation, why dissolving solid $NaHCO_3$ in water produces a slightly basic solution. 2 marks

_____

_____

c. Under normal conditions, carbon dioxide is a gas. If the temperature and pressure are increased to critical levels, a supercritical fluid ($scCO_2$) forms. This fluid has properties midway between a liquid and a gas with the ability to extract a range of chemicals at low temperatures.

i. Carbon dioxide gas behaves like an ideal gas when temperatures are high, and pressures are low.

With reference to the interaction between particles, explain why carbon dioxide behaves like an ideal gas under these conditions. 2 marks

_____

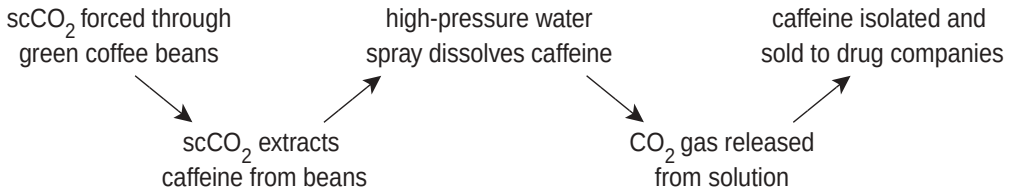
_____

_____

_____

_____

ii. In recent years, $scCO_2$ has been used in industry to extract caffeine from coffee beans in place of the toxic agents used in the past. The basic process is shown in the flowchart below.



Suggest one step which could be taken so that the CO_2 gas released from the solution does not increase the overall amount of CO_2 in the atmosphere. 1 mark

_____

_____

iii. The principles of green chemistry are listed in brief form below.

1. Prevent waste
2. Design safer chemicals and products
3. Design less hazardous chemical syntheses
4. Use renewable raw materials
5. Use catalysts, not stoichiometric reagents
6. Avoid chemical derivatives
7. Maximise atom economy
8. Use safer solvents and reaction conditions
9. Increase energy efficiency
10. Design for degradation
11. Analyse in real time to prevent pollution
12. Minimise the potential for accidents

Select **one** of these principles and circle its corresponding number. Explain how using $scCO_2$ to extract caffeine from coffee beans complies with the selected principle. 2 marks

_____

_____

_____

Question 4 (14 marks)

Human activities produce certain gases which are known to have detrimental effects on the atmosphere, the environment and human health.

a. In the table below, the involvement of some of these gases (labelled **A**–**D)** in environmental problems is shown.

	Photochemical smog	**Acid rain**	**Enhanced greenhouse effect**	**Ozone depletion**
A		*		
B	*			
C			*	*
D	*	*	*	

Identify the gases in the table above by writing one of the letters **A**–**D** in each of the spaces below. 4 marks

Chlorofluorocarbons	**Oxides of nitrogen**	**Carbon monoxide**	**Sulfur dioxide**

b. Methane gas has also been shown to contribute to the enhanced greenhouse effect. Some industries produce methane gas as a waste by-product. Rather than releasing this gas directly into the atmosphere, it is better for the environment to burn the waste methane in excess oxygen.

i. Write a balanced equation to represent the complete combustion of methane (CH_4). 2 marks

_____

ii. Why is burning the methane preferable to its direct release into the atmosphere, even though the gaseous products of the combustion also contribute to the enhanced greenhouse effect? 1 mark

_____

_____

_____

iii. Methane gas is often burnt in large glass structures known as hot houses which are used to grow plants when the outside temperature is too low.

Give **two** ways in which plant growth is assisted by burning methane. 2 marks

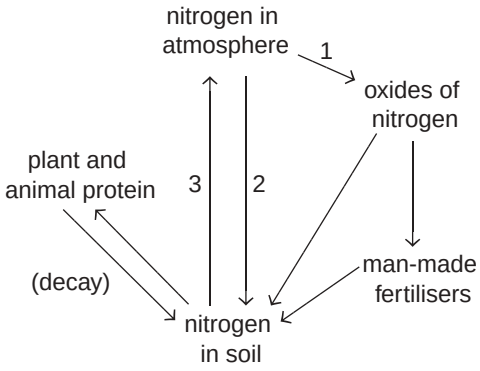
_____

_____

_____

_____

c. The oxides of nitrogen play an important role in the nitrogen cycle:



i. Apart from fertiliser manufacture, what human activity results in the process labelled 1? 1 mark

_____

ii. Write a balanced chemical equation for the process labelled 1. 1 mark

_____

iii. What is the name given to the process labelled 2? 1 mark

_____

iv. How does the process labelled 3 occur? 1 mark

_____

v. Give the formula of a compound or ion which is a form of 'nitrogen in the soil'. 1 mark

_____

END OF QUESTION AND ANSWER BOOKLET