

1)

Which of the following has the highest boiling temperature?

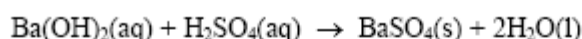
- ☐ A Pentane,  $\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_2\text{CH}_3$
- ☐ B Hexane,  $\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_2\text{CH}_2\text{CH}_3$
- ☐ C 2-methylbutane,  $\text{CH}_3\text{CH}(\text{CH}_3)\text{CH}_2\text{CH}_3$
- ☐ D 2-methylpentane,  $\text{CH}_3\text{CH}(\text{CH}_3)\text{CH}_2\text{CH}_2\text{CH}_3$

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(Total for Question = 1 mark)

2)

20 cm<sup>3</sup> of sulfuric acid, concentration 0.25 mol dm<sup>-3</sup>, was neutralized in a titration with barium hydroxide, concentration 0.50 mol dm<sup>-3</sup>. The equation for the reaction is



(a) The volume of barium hydroxide required was

(1)

- ☐ A 10 cm<sup>3</sup>
- ☐ B 20 cm<sup>3</sup>
- ☐ C 25 cm<sup>3</sup>
- ☐ D 40 cm<sup>3</sup>

(b) During the titration, the barium hydroxide was added until it was present in excess. The electrical conductivity of the titration mixture

(1)

- ☐ A increased steadily.
- ☐ B decreased steadily.
- ☐ C increased and then decreased.
- ☐ D decreased and then increased.

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(Total for Question = 2 marks)

3)

When chloroethane is heated with a concentrated solution of potassium hydroxide in ethanol, the reaction which occurs is

- ☐ A substitution.
- ☐ B elimination.
- ☐ C hydrolysis.
- ☐ D redox.

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(Total for Question = 1 mark)

4)

Which of the following molecules does **not** absorb infrared radiation?

- ☐ A  $\text{N}_2$
- ☐ B  $\text{NO}_2$
- ☐ C  $\text{CO}$
- ☐ D  $\text{CO}_2$

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(Total for Question = 1 mark)

5)

There would be a major peak in the mass spectrum for butan-1-ol,  $\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_2\text{OH}$ , but **not** for butan-2-ol,  $\text{CH}_3\text{CH}_2\text{CH}(\text{OH})\text{CH}_3$ , at  $m/e$  value

- ☐ A 15
- ☐ B 17
- ☐ C 29
- ☐ D 43

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(Total for Question = 1 mark)

6)

How many molecular ion peaks (parent ion peaks) occur in the mass spectrum of 1,2-dibromoethane,  $\text{CH}_2\text{BrCH}_2\text{Br}$ ?

Assume the only isotopes present are  $^1\text{H}$ ,  $^{12}\text{C}$ ,  $^{79}\text{Br}$  and  $^{81}\text{Br}$ .

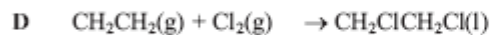
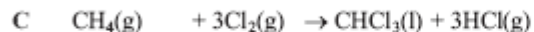
- ☐ A 1
- ☐ B 2
- ☐ C 3
- ☐ D 4

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(Total for Question = 1 mark)

7)

The following reactions have been used in the chemical industry to make liquid and solid products, allowing any gaseous products to escape into the atmosphere:



(a) Which reaction has an atom economy by mass of 56%?

- ☐ A (1)
- ☐ B
- ☐ C
- ☐ D

(b) Which reaction causes the most immediate damage to the environment?

- ☐ A (1)
- ☐ B
- ☐ C
- ☐ D

(c) Which reaction is an electrophilic addition?

- ☐ A (1)
- ☐ B
- ☐ C
- ☐ D

(Total for Question = 3 marks)

8)

Propan-1-ol and propan-2-ol are separately oxidized under mild conditions by acidified sodium dichromate(VI) and the product immediately distilled off. What is the oxidation product in each case?

		Propan-1-ol	Propan-2-ol
<input type="checkbox"/>	A	propanal	propanone
<input type="checkbox"/>	B	propanoic acid	propanone
<input type="checkbox"/>	C	propanal	propanoic acid
<input type="checkbox"/>	D	propanone	propanal

(Total for Question = 1 mark)

9)

Unsaturated vegetable oils are hardened to make margarine by reaction with hydrogen and a nickel catalyst. Which terms could both be used to describe this type of reaction?

- ☐ A Substitution and oxidation
- ☐ B Substitution and reduction
- ☐ C Addition and oxidation
- ☐ D Addition and reduction

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(Total for Question = 1 mark)

10)

When iodomethane,  $\text{CH}_3\text{I}$ , is heated in a sealed tube with an excess of alcoholic ammonia, which of the following **cannot** be formed?

- ☐ A Methylamine,  $\text{CH}_3\text{NH}_2$
- ☐ B Ethylamine,  $\text{CH}_3\text{CH}_2\text{NH}_2$
- ☐ C Dimethylamine,  $(\text{CH}_3)_2\text{NH}$
- ☐ D Ammonium iodide,  $\text{NH}_4\text{I}$

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(Total for Question = 1 mark)

11)

The enthalpy change of neutralization of an acid by an alkali is measured by adding  $10.0\text{ cm}^3$  of hydrochloric acid to  $10.0\text{ cm}^3$  of sodium hydroxide.  $10.0\text{ cm}^3$  pipettes with an accuracy of  $\pm 0.04\text{ cm}^3$  are used to measure out both solutions.

The overall percentage error in measuring the total volume of the reaction mixture is

- ☐ A  $\pm 0.04\%$
- ☐ B  $\pm 0.08\%$
- ☐ C  $\pm 0.4\%$
- ☐ D  $\pm 4.0\%$

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(Total for Question = 1 mark)

12)

This question is about the element chlorine and its compounds.

- (a) When chlorine is bubbled through water, a solution of chlorine water forms. What is the colour of chlorine water?

(1)

- (b) Chlorine water is added to potassium iodide solution.

- (i) State the colour of the solution produced.

(1)

- (ii) Write the **ionic** equation for the reaction, including state symbols.

(2)

- (c) The concentration of chlorine water was found by taking 10.0 cm<sup>3</sup> of solution, adding an excess of potassium iodide solution, and titrating with 0.0100 mol dm<sup>-3</sup> of sodium thiosulfate solution. The experiment was repeated.

The following results were obtained.

Titration number	1	2
Final burette reading / cm <sup>3</sup>	38.60	47.60
Initial burette reading / cm <sup>3</sup>	29.50	38.60
Volume added / cm <sup>3</sup>	9.10	9.00

- (i) Name a suitable indicator for the titration. State the colour change you would expect to see at the end point.

(2)

Indicator .....

Colour change from ..... to .....

- (ii) Calculate the mean titre and use this value to calculate the number of moles of sodium thiosulfate used in the titration.

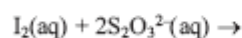
(1)

Mean titre = .....  $\text{cm}^3$ 

Moles of sodium thiosulfate

- (iii) Complete the ionic equation for the reaction between iodine and thiosulfate ions.

(2)



- (iv) Calculate the number of moles of iodine which reacted with the sodium thiosulfate solution.

(1)

- (v) Hence state the number of moles of chlorine present in  $10.0 \text{ cm}^3$  of the chlorine

- (vi) Calculate the concentration of the chlorine water, in  $\text{mol dm}^{-3}$ .

(1)

- (d) Potassium burns in chlorine to form potassium chloride.

- (i) Give the colour of the flame when potassium burns in chlorine.

(1)

- (ii) Write the equation for the reaction between potassium and chlorine. State symbols are **not** required.

(1)

- (e) Concentrated sulfuric acid is added to potassium chloride in a test tube. Steamy fumes are given off which react with ammonia to give dense white smoke.

- (i) Name the gas given off in this reaction.

(1)

- ... (ii) Steamy fumes are observed at the mouth of the test tube. Explain how these fumes are formed.

(1)

- ... (iii) The steamy fumes react with ammonia to give a dense white smoke. Identify the white smoke by name or formula.

(1)

- ... (f) 2-chlorobutane can be made from butan-2-ol.

- (i) Name the chemical you would add to butan-2-ol in the laboratory to make 2-chlorobutane.

...

- (ii) 2-chlorobutane reacts with alcoholic potassium hydroxide at a high temperature to form a mixture of gaseous alkenes.

Draw a fully labelled diagram of the apparatus you would use to prepare and collect this mixture.

(3)

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(Total for Question = 21 marks)

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13)

This question is about ethanethiol,  $\text{CH}_3\text{CH}_2\text{SH}$ . Thiols are like alcohols, but the oxygen atom has been replaced by a sulfur atom. They react in a similar way to alcohols.

- (a) (i) Draw a dot and cross diagram for ethanethiol, showing outer electrons only.

(2)

- (ii) Give the value for the CSH bond angle in ethanethiol. Justify your answer.

(3)

CSH angle .....

Justification .....

- (b) There are hydrogen bonds between ethanol molecules but not between ethanethiol molecules.

- (i) Explain why the bond angle around the hydrogen atom involved in a hydrogen bond is  $180^\circ$ .

(2)

- (ii) Explain why there are no hydrogen bonds between ethanethiol molecules.

(1)

- (c) (i) Describe the formation of London forces.

(2)

- (ii) Explain why the London forces in ethanethiol are stronger than those in ethanol.

(1)

- (d) The reaction of sodium with ethanethiol,  $\text{CH}_3\text{CH}_2\text{SH}$ , is similar to its reaction with ethanol.

- (i) Suggest one observation you would make when sodium is added to ethanethiol.

(1)

- (ii) Suggest a balanced equation for this reaction. State symbols are **not** required.

(1)

(e) Ethanol can be made from bromoethane by reaction with aqueous potassium hydroxide,  $\text{KOH(aq)}$ , under suitable conditions.

(i) Write the equation for this reaction. State symbols are **not** required.

(1)

(ii) State the type and mechanism of this reaction.

(2)

Type .....

Mechanism .....

(iii) Suggest the formula of a suitable chemical to make ethanethiol from bromoethane.

(1)

(f) When ethanethiol undergoes complete combustion in air, a gas is produced which is not formed on the complete combustion of ethanol. Identify the gas and suggest why it is damaging to the environment.

(2)

(Total for Question ... = 19 marks)

14)

This question is about nitrogen monoxide,  $\text{NO}$ , which can be described both as a friend and a foe.

Chemists have discovered that nitrogen monoxide plays an important role in the body by dilating blood vessels. If someone is suffering from blood circulatory or heart problems, a chemical may be given which will quickly break down to give nitrogen monoxide. Years ago, nitroglycerine was used for this purpose. Interestingly, the same chemical Nobel had used to make dynamite was used to treat him in old age.

In the laboratory, nitrogen monoxide can be prepared by adding concentrated nitric acid to powdered silver. Nitrogen monoxide is a colourless gas which is partially soluble in water. It is difficult to detect its smell, because it reacts with oxygen in the air to form pungent-smelling nitrogen dioxide.

Nitrogen monoxide is formed when a mixture of air and oxygen is heated to a high temperature. This reaction occurs in the engines of cars and aeroplanes. Nitrogen monoxide has a disastrous effect on the ozone layer because it is a free radical. Nitrogen monoxide is also a greenhouse gas.

(a) (i) What is meant by the term **free radical**?

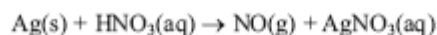
(1)

(ii) Suggest a dot and cross diagram for nitrogen monoxide, showing outer shell electrons only, remembering that it is a free radical.

(2)



- (b) (i) Part of the unbalanced equation for the preparation of nitrogen monoxide from nitric acid is shown below.



Identify the elements which are oxidized and reduced and give their oxidation numbers.

(3)

Element oxidized .....

Oxidation number initial ..... final .....

Element reduced .....

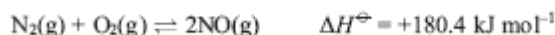
Oxidation number initial ..... final .....

- (ii) Complete and balance the equation for the reaction between silver and nitric acid.

(2)



- (c) The reaction between nitrogen and oxygen to form nitrogen monoxide reaches equilibrium.



- (i) Explain why the yield of nitrogen monoxide is increased when the temperature is increased.

(1)

- \*(ii) State and explain the effect, if any, on the yield of nitrogen monoxide when the pressure is increased.

(2)

- (iii) State and explain how the rate of the reaction is affected by an increase in pressure.

(2)

- \*(d) (i) Explain why a jet aeroplane in flight causes much more damage to the ozone layer than cars carrying the same number of passengers at sea level. You should assume that the nitrogen monoxide outputs for both methods of conveying the passengers are the same.

(2)

- (ii) The reactions of chlorine free radicals with ozone may be represented by the following equations.



Write corresponding equations for the reactions of the free radical nitrogen monoxide with ozone. Combine your two equations to show the overall reaction.

Use these equations to explain why a small quantity of nitrogen monoxide can have a continuing effect on the ozone layer.

(5)

Equations

Explanation .....

