AH

National
Qualifications
SPECIMEN ONLY

SQ05/AH/02

**Chemistry
Section 1 — Questions**

Date — Not applicable

Duration — 2 hours 30 minutes

Instructions for the completion of Section 1 are given on *Page two* of your question and answer booklet SQ05/AH/01.

Record your answers on the answer grid on *Page three* of your question and answer booklet.

Reference may be made to the Chemistry Higher and Advanced Higher Data Booklet.

Before leaving the examination room you must give your question and answer booklet to the Invigilator; if you do not you may lose all the marks for this paper.

SQ05AH02

SECTION 1 — 30 marks

Attempt ALL questions

1. An element X forms an ion, X^{3+}, which contains 55 electrons.

   In which block of the Periodic Table would element X be found?

   A   s

   B   p

   C   d

   D   f

2. Which one of the following metal salts will emit radiation of the highest frequency when placed in a Bunsen flame?

   A   Copper(II) chloride

   B   Potassium chloride

   C   Barium chloride

   D   Lithium chloride

3. The following diagram represents a square-planar structure.

   Where ◤ and ◤ represent bonding electron pairs

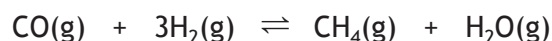   and ⊙ represents a non-bonding electron pair (lone pair).

   Which of the following species could have the structure shown above?

   A SF_4

   B NH_4^+

   C XeF_4

   D AlH_4^-

4. A complex ion with the name hexaamminenickel(II) will have the formula

A $[Ni(NH_2)_6]^{2+}$

B $[Ni(NH_3)_6]^{2+}$

C $[Ni(NH_3)_6]^{4-}$

D $[Ni(NH_4)_6]^{2+}$.

5. The reaction

$$CO(g) + 3H_2(g) \rightleftharpoons CH_4(g) + H_2O(g)$$

has an equilibrium constant of 3·9 at 950 °C.

The equilibrium concentrations of CO(g), $H_2(g)$ and $H_2O(g)$ at 950 °C are given in the table.

Substance	Equilibrium concentration/mol l^{-1}
CO(g)	$5·0 \times 10^{-2}$
$H_2(g)$	$1·0 \times 10^{-2}$
$H_2O(g)$	$4·0 \times 10^{-3}$

What is the equilibrium concentration of $CH_4(g)$, in mol l^{-1}, at 950 °C?

A $4·9 \times 10^{-1}$

B $3·1 \times 10^{-5}$

C $4·9 \times 10^{-5}$

D $2·0 \times 10^{-7}$

6. Which of the following decreases when an aqueous solution of ethanoic acid is diluted?

A pH

B $[H^+]$

C pK_a

D K_a

7. The pH of a buffer solution prepared by mixing equal volumes of 0·1 mol l^{-1} ethanoic acid and 0·2 mol l^{-1} sodium ethanoate is

A 2·1

B 2·7

C 4·5

D 5·1.

8. The graph below shows the pH changes when $0.1\,mol\,l^{-1}$ ammonia solution is added to $50\,cm^3$ of $0.1\,mol\,l^{-1}$ hydrochloric acid solution.

Volume of $0.1\,mol\,l^{-1}\,NH_3$ added$/cm^3$
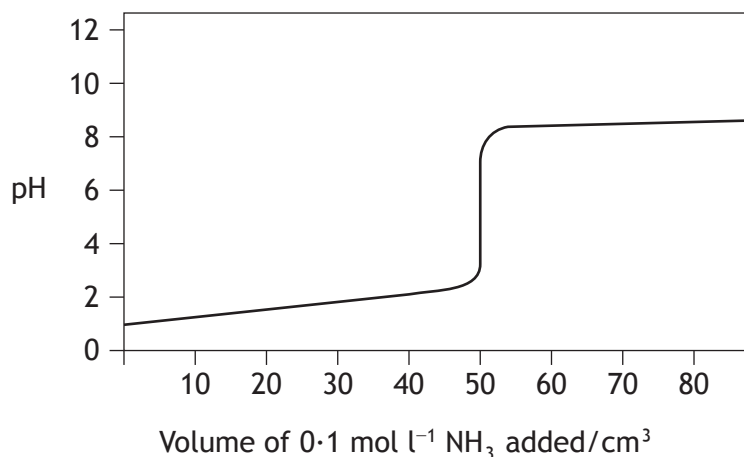
Which line in the table shows an indicator which is **not** suitable for use in determining the equivalence point for the above reaction?

	Indicator	pH range of indicator
A	methyl orange	$3.1-4.4$
B	bromophenol red	$5.2-6.8$
C	bromothymol blue	$6.0-7.6$
D	phenolphthalein	$8.3-10.0$

9. Ethanoic acid is a weak acid and hydrochloric acid is a strong acid. Which of the following is **not** true?

A   The pH of $0.1\,mol\,l^{-1}$ hydrochloric acid is 1.

B $20.0\,cm^3$ of $0.1\,mol\,l^{-1}$ sodium hydroxide is exactly neutralised by $20.0\,cm^3$ of $0.1\,mol\,l^{-1}$ ethanoic acid.

C   The pH of $0.1\,mol\,l^{-1}$ hydrochloric acid is lower than that of $0.1\,mol\,l^{-1}$ ethanoic acid.

D   The K_a value for ethanoic acid is greater than that of hydrochloric acid.

10. The standard enthalpy of formation of strontium chloride is the enthalpy change for which of the following reactions?

A $Sr(g) + Cl_2(g) \rightarrow SrCl_2(s)$

B $Sr(s) + Cl_2(g) \rightarrow SrCl_2(s)$

C $Sr^{2+}(g) + 2Cl^-(g) \rightarrow SrCl_2(s)$

D $Sr^{2+}(aq) + 2Cl^-(aq) \rightarrow SrCl_2(s)$

11. Which of the following alcohols would have the greatest entropy at 90 °C?

    A   Propan-1-ol

    B   Butan-1-ol

    C   Propan-2-ol

    D   Butan-2-ol

12. For any liquid, $\Delta S_{vaporisation} = \dfrac{\Delta H_{vaporisation}}{T_b}$

where T_b = boiling point of that liquid.

For many liquids, $\Delta S_{vaporisation} = 88\ J\,K^{-1}\,mol^{-1}$.

Assuming that this value is true for water and that its
$\Delta H_{vaporisation} = 40\cdot6\ kJ\,mol^{-1}$, then the boiling point of water is calculated as

    A   0·46 K

    B   2·17 K
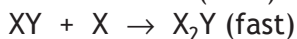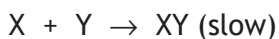
    C   373 K

    D   461 K.

13. The order of a reactant in a reaction

    A   can only be obtained by experiment

    B   determines the speed of the overall reaction

    C   is determined by the stoichiometry involved

    D   is the sequence of steps in the reaction mechanism.

14. A suggested mechanism for the reaction

$2X + Y \rightarrow X_2Y$

is a two-step process

$X + Y \rightarrow XY$ (slow)
$XY + X \rightarrow X_2Y$ (fast)

This mechanism is consistent with which of the following rate equations?

    A   Rate = k[XY]

    B   Rate = k[X][Y]

    C   Rate = k[X]^2[Y]

    D   Rate = k[X][XY]

15. What volume of $0.2\,mol\,l^{-1}$ potassium sulfate is required to make, by dilution with water, one litre of a solution with a **potassium** ion concentration of $0.1\,mol\,l^{-1}$?

A $\quad 500\,cm^3$

B $\quad 400\,cm^3$

C $\quad 250\,cm^3$

D $\quad 100\,cm^3$

16. The end-on overlap of two atomic orbitals lying along the axis of a bond leads to

A $\quad$ hydridisation

B $\quad$ a sigma bond

C $\quad$ a pi bond

D $\quad$ a double bond.

17. Which of the following has nucleophilic properties?

A $\quad$ Na

B $\quad$ Br^+

C $\quad$ CH_3^+

D $\quad$ NH_3

18. Carbonyl groups in aldehydes and ketones react with HCN and the product can then be hydrolysed forming a 2-hydroxycarboxylic acid as shown in the equation below.
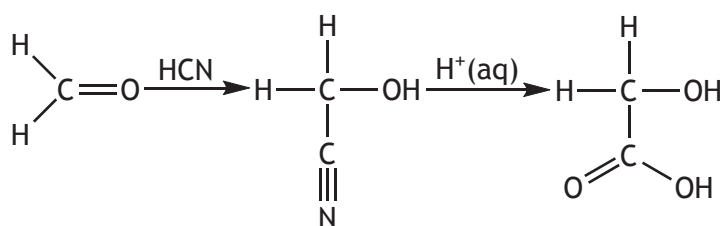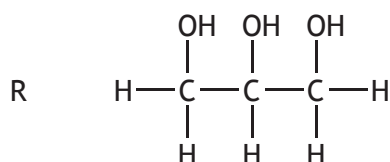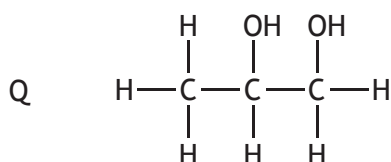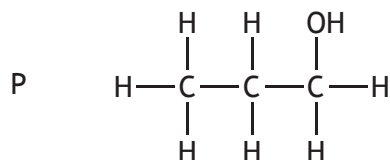

When the final product is 2-hydroxy-2-methylbutanoic acid, the starting carbonyl compound is

A $\quad$ propanol

B $\quad$ propanone

C $\quad$ butanal

D $\quad$ butanone.

19. Which of the following is a tertiary haloalkane?

A $CHCl_3$

B $(CH_3)_3CCl$

C $(CH_2Cl)_3CH$

D $(CH_3)_3CCH_2Cl$

20. The structures of three alcohols, P, Q and R are shown.

P

$$\begin{array}{ccccccc} & H & & H & & OH & \\ & | & & | & & | & \\ H-&C&-&C&-&C&-H \\ & | & & | & & | & \\ & H & & H & & H & \end{array}$$

Q

$$\begin{array}{ccccccc} & H & & OH & & OH & \\ & | & & | & & | & \\ H-&C&-&C&-&C&-H \\ & | & & | & & | & \\ & H & & H & & H & \end{array}$$

R

$$\begin{array}{ccccccc} & OH & & OH & & OH & \\ & | & & | & & | & \\ H-&C&-&C&-&C&-H \\ & | & & | & & | & \\ & H & & H & & H & \end{array}$$

Which line in the table describes the trends in boiling points and viscosities on moving from P to Q to R?

|	Boiling point	Viscosity
A	increases	increases
B	increases	decreases
C	decreases	increases
D	decreases	decreases

21. The Williamson synthesis for the preparation of unsymmetrical ethers (ROR') starting with an alcohol and a haloalkane is summarised in the general equations:

Step 1: $ROH + Na \rightarrow RO^-Na^+ + \frac{1}{2}H_2$
Step 2: $RO^-Na^+ + R'X \rightarrow ROR' + Na^+X^-$
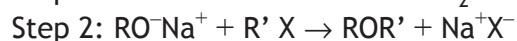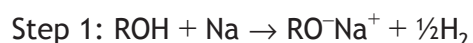
Using propan-2-ol and 2-chlorobutane, the unsymmetrical ether formed would be

A $CH_3CH_2CH_2OCH(CH_3)CH_2CH_3$

B $CH_3CH_2CH_2OCH_2CH_2CH_2CH_3$

C $CH_3CH(CH_3)OCH_2CH_2CH_2CH_3$

D $CH_3CH(CH_3)OCH(CH_3)CH_2CH_3$.

22.

propan-1-ol

$\downarrow$ (1)

1-chloropropane

(2) $\swarrow$ $\searrow$ (3)

propene   methoxypropane
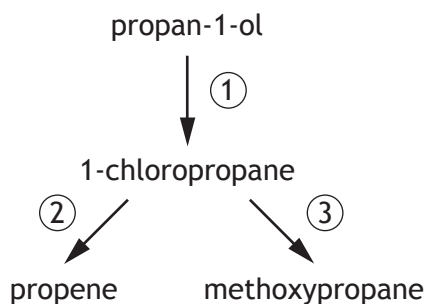
Which line in the table is correct for the types of reaction taking place at (1), (2) and (3)?

	Reaction (1)	*Reaction* (2)	*Reaction* (3)
A	substitution	elimination	substitution
B	substitution	reduction	substitution
C	addition	reduction	condensation
D	addition	elimination	substitution

23. P

—Cl

Q $CH_2=CHCl$

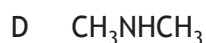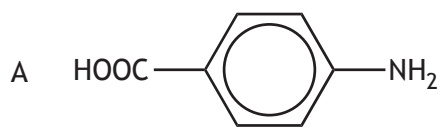R $CH_2=CHCH_2Cl$
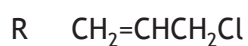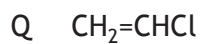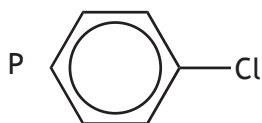
Which of the above molecules is/are planar?

A   P only

B   Q and R only

C   P and Q only

D   P, Q and R

24. One mole of which of the following compounds will react with the largest volume of $1\,mol\,l^{-1}$ hydrochloric acid?

A   HOOC—⬡—NH_2

B $HOOCCH_2NH_2$

C $H_2NCH_2NH_2$

D CH_3NHCH_3

25. Which of the following amines shows no infra-red absorption between $3300\,cm^{-1}$ and $3500\,cm^{-1}$?

A $(CH_3)_3N$

B CH_3NHCH_3

C $H_2NCH_2NH_2$

D   ⬡—NH_2
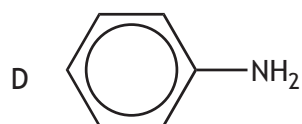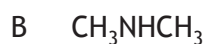
26. Which of the following reactions is **least** likely to take place?

A   ⬡ $\xrightarrow{Br_2/AlCl_3}$ ⬡—Br

B   ⬡ $\xrightarrow{Br_2/light}$ ⬡—Br

C   ⬡—CH_3 $\xrightarrow{Br_2/light}$ ⬡—CH_2Br

D   ⬡ $\xrightarrow{H_2SO_4/SO_3}$ ⬡—SO_3H
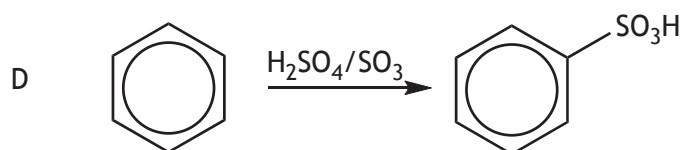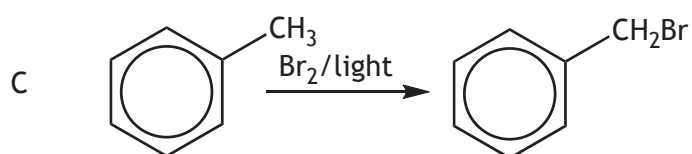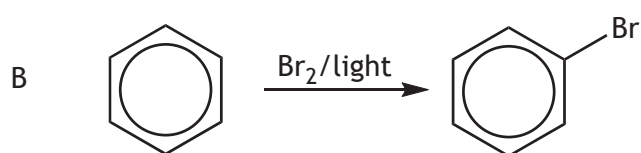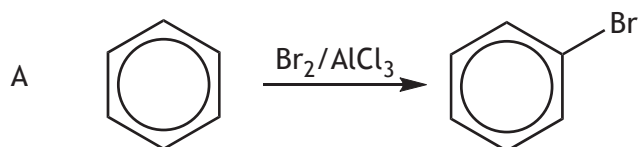
27. Which of the following analytical techniques would be most suitable to determine quantitatively the concentration of sodium ions in a urine sample?

A   Mass spectrometry

B   Infra-red spectroscopy

C   Atomic emission spectroscopy

D   Proton nuclear magnetic resonance spectroscopy

28. The hydrolysis of the haloalkane $(CH_3)_3CBr$ was found to take place by an S_N1 mechanism.

The rate determining step involved the formation of

A

B

C

D

.
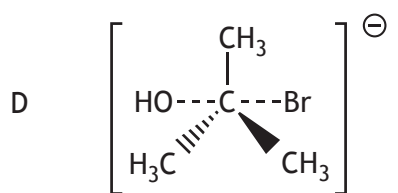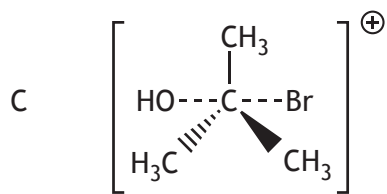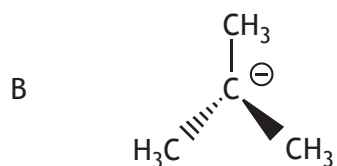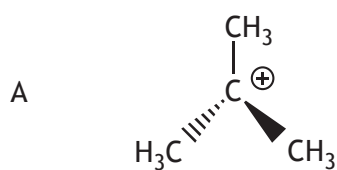
29. One of the splitting patterns seen in the high resolution ^1H NMR spectrum of 3-methylbutan-1-ol below is shown.
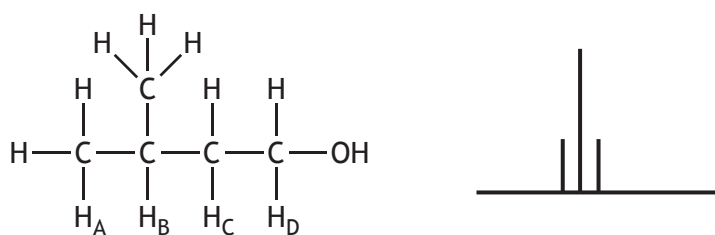
3-methylbutan-1-ol

Which of the following H atoms, H_A, H_B, H_C and H_D, would produce this splitting pattern?

A H_A

B H_B

C H_C

D H_D

30. The table shows the structural formulae of some sulfonamides and their antibacterial activity.

Sulfonamide	Antibacterial activity
$H-N(H)-C_6H_4-SO_2-N(H)-CH_3$	Active
$H-N(H)-C_6H_4-SO_2-N(H)-H$	Active
$H-N(H)-C_6H_4-SO_2-OH$	Inactive
$H_3C-N(H)-C_6H_4-SO_2-N(H)-CH_3$	Inactive

Which of the following would be an active antibacterial agent?

A

B

C

D
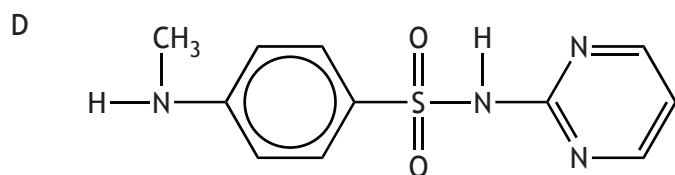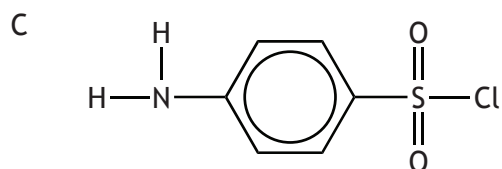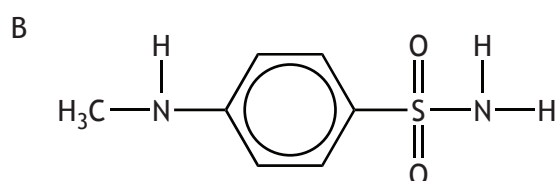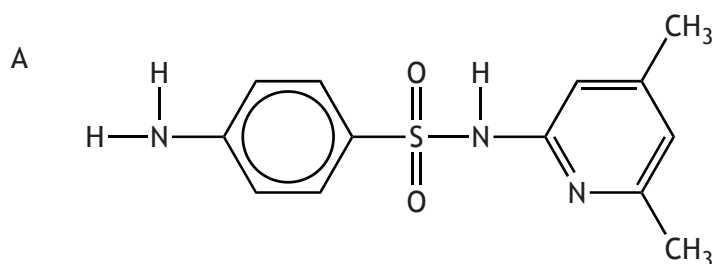
[END OF SECTION 1. NOW ATTEMPT THE QUESTIONS IN SECTION 2 OF YOUR QUESTION AND ANSWER BOOKLET.]

Page twelve

AH

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Mark

SQ05/AH/01

**Chemistry
Section 1—Answer Grid
and Section 2**

Date — Not applicable

Duration — 2 hours 30 minutes

SQ05AH01

Fill in these boxes and read what is printed below.

Full name of centre

Town

Forename(s)

Surname

Number of seat

Date of birth

Day	Month	Year	Scottish candidate number

Reference may be made to the Chemistry Higher and Advanced Higher Data Booklet.

Total marks — 100

SECTION 1 — 30 marks

Attempt ALL questions.

Instructions for completion of Section 1 are given on *Page two*.

SECTION 2 — 70 marks

Attempt ALL questions

Write your answers clearly in the spaces provided in this booklet. Additional space for answers and rough work is provided at the end of this booklet. If you use this space you must clearly identify the question number you are attempting. Any rough work must be written in this booklet. You should score through your rough work when you have written your final copy.

Use **blue** or **black** ink.

Before leaving the examination room you must give this booklet to the Invigilator; if you do not, you may lose all the marks for this paper.

SQA

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SQ05AH0101

The questions for Section 1 are contained in the question paper SQ05/AH/02.
Read these and record your answers on the answer grid on *Page three* opposite.
Do NOT use gel pens.

1. The answer to each question is **either** A, B, C or D. Decide what your answer is, then fill in the appropriate bubble (see sample question below).

2. There is **only one correct** answer to each question.

3. Any rough working should be done on the additional space for answers and rough work at the end of this booklet.

Sample Question

To show that the ink in a ball-pen consists of a mixture of dyes, the method of separation would be:

    A   fractional distillation

    B   chromatography

    C   fractional crystallisation

    D   filtration.

The correct answer is **B**—chromatography. The answer **B** bubble has been clearly filled in (see below).

Changing an answer

If you decide to change your answer, cancel your first answer by putting a cross through it (see below) and fill in the answer you want. The answer below has been changed to **D**.

If you then decide to change back to an answer you have already scored out, put a tick (✓) to the **right** of the answer you want, as shown below:

	A	B	C	D
1	◯	◯	◯	◯
2	◯	◯	◯	◯
3	◯	◯	◯	◯
4	◯	◯	◯	◯
5	◯	◯	◯	◯
6	◯	◯	◯	◯
7	◯	◯	◯	◯
8	◯	◯	◯	◯
9	◯	◯	◯	◯
10	◯	◯	◯	◯
11	◯	◯	◯	◯
12	◯	◯	◯	◯
13	◯	◯	◯	◯
14	◯	◯	◯	◯
15	◯	◯	◯	◯
16	◯	◯	◯	◯
17	◯	◯	◯	◯
18	◯	◯	◯	◯
19	◯	◯	◯	◯
20	◯	◯	◯	◯
21	◯	◯	◯	◯
22	◯	◯	◯	◯
23	◯	◯	◯	◯
24	◯	◯	◯	◯
25	◯	◯	◯	◯
26	◯	◯	◯	◯
27	◯	◯	◯	◯
28	◯	◯	◯	◯
29	◯	◯	◯	◯
30	◯	◯	◯	◯

SECTION 2 — 70 marks

Attempt ALL questions

1. In 2002, astronomers observed a red giant star flash 10 000 times brighter than normal. Its electromagnetic spectrum revealed an intense crimson red line, wavelength 670·7 nm.

(a) Identify an element present in the red giant star that could be responsible for this intense crimson red line in the emission spectrum. **1**

(b) Explain how the line of red light is produced. **2**

(c) Calculate the energy, in kJ mol^{-1}, associated with this wavelength. **2**

2. Most commercial bleaches contain hypochlorous acid. This acid dissociates as follows:

$$HClO(aq) \quad + \quad H_2O(\ell) \quad \rightleftharpoons \quad H_3O^+(aq) \quad + \quad ClO^-(aq)$$
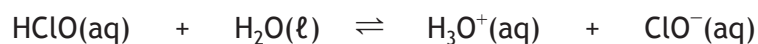
(a) Identify the conjugate base of hypochlorous acid. **1**

(b) Write the expression for the dissociation constant, K_a, for hypochlorous acid. **1**

(c) A solution of hypochlorous acid was titrated with sodium hydroxide solution.

The solution at the end point was alkaline.

Explain why the solution at the end point was alkaline. **2**

3. β-carotene is an orange substance and is one of the compounds responsible for the colour of carrots and autumn leaves.
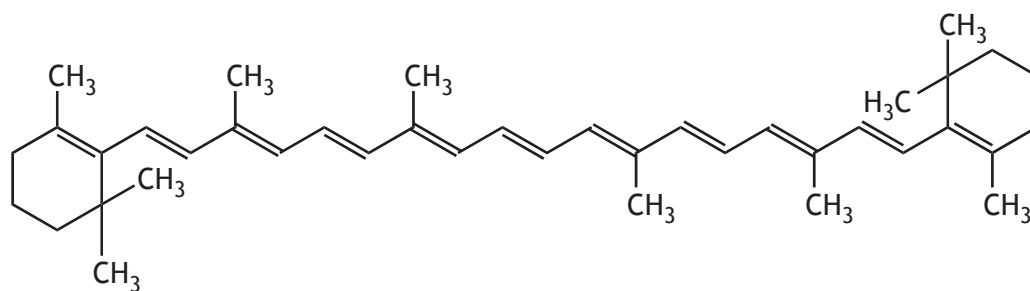
β-carotene

Using your knowledge of chemistry, comment on why compounds, such as β-carotene, are the colour they are.

3

4. The ore pyrolusite, MnO_2, was used 30 000 years ago as a black pigment in the cave paintings of Lascaux, France.

The best known oxide of manganese is possibly potassium permanganate, $KMnO_4$, first made in 1740 for the glass industry. It now has many uses including disinfectants and the removal of organic impurities from waste gases and effluent water.

(a)   (i) State the oxidation number of manganese in MnO_2.   **1**

(ii) Using orbital box notation, write the electronic configuration for a manganese ion in MnO_2.   **1**

(iii) Explain how your answer is consistent with Hund's rule.   **1**

(b)   (i) The d orbitals in an isolated manganese atom are degenerate. State the meaning of the term degenerate.   **1**

4. **(b)** **(continued)**

    (ii) The second quantum number, ℓ, is related to the shape of the orbitals.

    Draw the shape of an orbital when $\ell = 1$.   **1**

(c) Small amounts of manganese are added to the aluminium used for drinks cans to improve their corrosion resistance. The technique of colorimetry can be used to determine the quantity of manganese in these alloys and involves converting the manganese to permanganate ions, MnO_4^-.

    (i) Describe how the technique of colorimetry can be used to determine the concentration of permanganate ions.   **3**

    (ii) During colorimetric analysis, $0 \cdot 35\,g$ of an aluminium alloy was dissolved in nitric acid. The manganese in the resulting solution was oxidised and the solution was made up to $250\,cm^3$.

    The concentration of this solution was found to be $4 \cdot 25 \times 10^{-4}\,mol\,l^{-1}$.

    Calculate the percentage, by mass, of manganese in the alloy.   **2**

5. A student was investigating the percentage calcium carbonate content in different types of egg shells. The egg shells were ground and approximately 0·4 g were weighed accurately. The shells were placed in a beaker and 20·0 cm³ of 1·00 mol l⁻¹ hydrochloric acid was added. Once the reaction was complete, the solution was made up to 100·0 cm³ in a standard flask.

$$CaCO_3(s) + 2HCl(aq) \rightarrow CaCl_2(aq) + CO_2(g) + H_2O(\ell)$$

(a) State what is meant by weighing accurately, approximately 0·4 g. **1**

(b) Describe the steps required to prepare the 100·0 cm³ solution. **2**

(c) 10·0 cm³ aliquots of the solution were titrated against 0·100 mol l⁻¹ standardised sodium hydroxide solution using phenolphthalein as an indicator until concordant results were obtained.

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

(i) State why the sodium hydroxide solution had to be standardised. **1**

5. (c) (continued)

    (ii) An egg shell sample of 0·390 g was used in this experiment.

       This led to an average titre volume of 12·65 cm^3.

       Calculate the percentage, by mass, of calcium carbonate present in the egg shell.

4

6. Omeprazole is a drug commonly used to prevent stomach ulcers. It is described as a proton pump inhibitor as it reduces the ability of enzymes to produce gastric acid. Omeprazole exhibits optical isomerism and is sold as a mixture of both enantiomers.
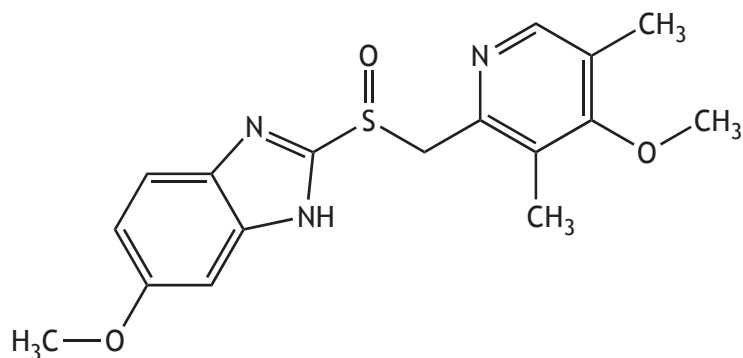
omeprazole

(a) Write the molecular formula for omeprazole. **1**

(b) State the name given to a mixture containing equal amounts of both enantiomers. **1**

(c) Suggest the drug classification that best describes omeprazole. **1**

(d) Only one omeprazole enantiomer, known as esomeprazole, is active. However, in acidic environments the other, inactive, enantiomer is converted into the active one.

　　(i) Explain the benefit of selling the drug as an equal mixture of both enantiomers. **1**

6. (d) (continued)

(ii) The first stage of the conversion of the inactive enantiomer involves the reaction with H$^+$ ions as shown.

esomeprazole   compound X
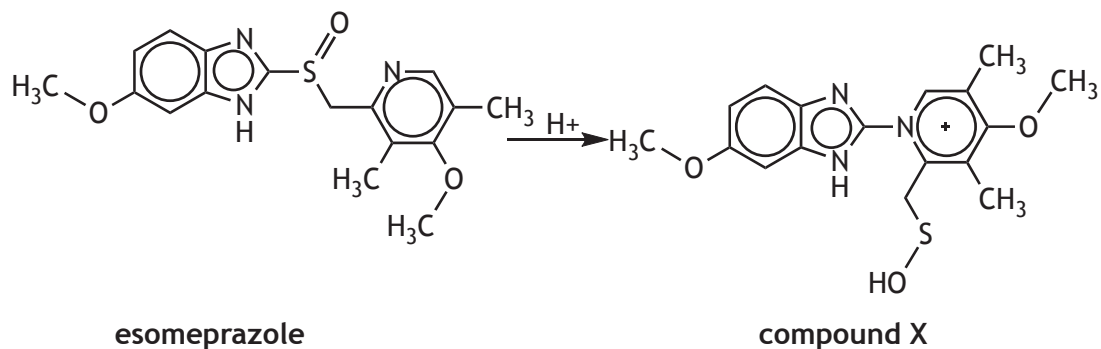
Identify a functional group that is present in compound X but not in esomeprazole.

1

7. To make nuclear fuel from uranium ore, the element uranium has to be extracted from the ore before being made into fuel pellets.

One of the reactions in the production of nuclear fuel from uranium ore is

$$UO_2(s) \ + \ 4HF(g) \ \rightarrow \ UF_4(s) \ + \ 2H_2O(g) \qquad \Delta H^\circ \ = \ -244 \, kJ \, mol^{-1}$$
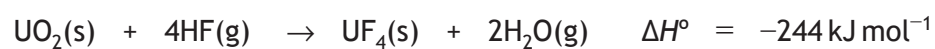
The data in the table below refers to the substances at 298 K.

Substance	$S^\circ / J \, K^{-1} mol^{-1}$
$UO_2(s)$	77
$HF(g)$	174
$UF_4(s)$	152
$H_2O(g)$	189

(a) Use the data to calculate the entropy change, in $J \, K^{-1} \, mol^{-1}$, at 298 K for this reaction.　　**2**

(b) Determine, by calculation, whether this reaction is feasible at 298 K.　　**3**

8. Benzocaine is used to relieve pain and itching caused by conditions such as sunburn, insect bites or stings.

$$O \diagdown \diagup OCH_2CH_3$$
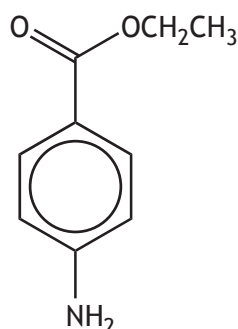
benzocaine

A student was carrying out a project to synthesise benzocaine. Part of the procedure to isolate the synthesised benzocaine is given below.

1. Add $20\,cm^3$ of diethyl ether to the reaction mixture and pour into a separating funnel.
2. Add $20\,cm^3$ of distilled water to the separating funnel.
3. Stopper the funnel, invert and gently shake.
4. Allow the aqueous layer to settle to the bottom.

(a)　(i) Name the technique described in this part of the procedure. **1**

　　(ii) Outline the next steps the student will need to carry out in order to obtain a maximum yield of solid benzocaine from the reaction mixture. **3**

　　(iii) State **two** properties the solvent must have for it to be appropriate for use in this procedure. **2**

8. **(continued)**

(b) Suggest a second technique that could be used to purify a solid sample of benzocaine. **1**

(c) Thin layer chromatography (TLC) was used to help confirm the identity of the product. A sample of product was dissolved in a small volume of solvent and spotted onto a TLC plate. The plate was allowed to develop and the following chromatogram was obtained.
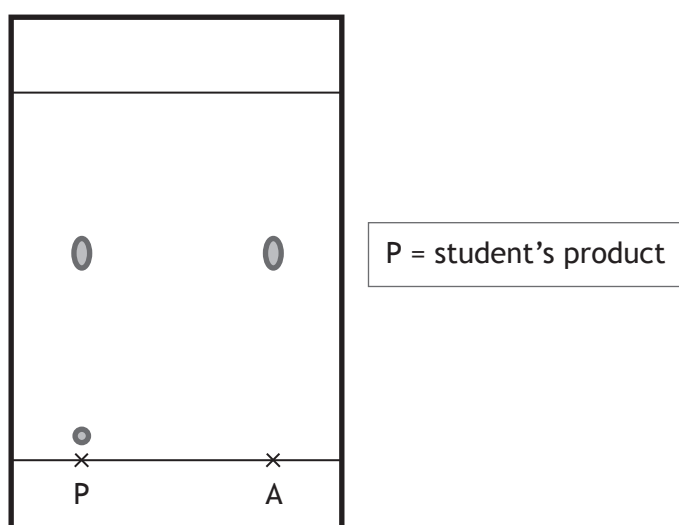
P = student's product

(i) State the name of the substance spotted at A on the TLC plate. **1**

(ii) Evaluate the purity of the student's product. **1**

9. At 1000 °C, nitric oxide can combine with hydrogen.

$$2NO(g) + 2H_2(g) \rightarrow N_2(g) + 2H_2O(g)$$
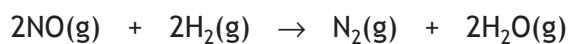
The rate of the above reaction was monitored at different concentrations of $NO(g)$ and $H_2(g)$. The results are shown in the table.

Experiment	[NO] mol l^{-1}	[H$_2$] mol l^{-1}	Initital rate/ mol l^{-1} s^{-1}
1	4.00×10^{-3}	1.00×10^{-3}	1.20×10^{-5}
2	8.00×10^{-3}	1.00×10^{-3}	4.80×10^{-5}
3	8.00×10^{-3}	4.00×10^{-3}	1.92×10^{-4}

(a) Determine the order of the reaction with respect to:

   (i) NO(g); **1**

   (ii) H$_2$(g). **1**

(b) Write the overall rate equation for the reaction. **1**

(c) Calculate a value for the rate constant, k, including the appropriate units. **2**

10. Pulegone, first isolated in 1891 from oil of pennyroyal, is a naturally occurring colourless oily liquid with an odour of peppermint. It is classified as a monoterpene and is used in perfumes and aromatherapy.
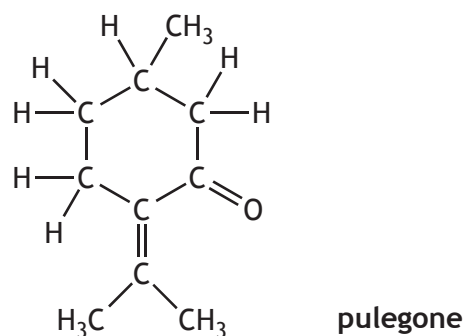
pulegone

(a) Circle the chiral centre on the structure of the pulegone above.

1

(b) Suggest the most appropriate spectroscopic method for identifying the carbonyl group in pulegone.

1

(c) If pulegone is treated with acid it is converted into two ketones, C_3H_6O and $C_7H_{12}O$.

Draw a possible structure for each of the ketones.

2

11. Cisplatin was the first member of a class of platinum-containing anti-cancer drugs.
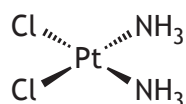
cisplatin

Clinical use of the drug is now limited since cancer cells can develop resistance to it.

(a)   (i) Explain the meaning of *cis* in cisplatin.   **1**

(ii) In the cisplatin complex, chloride ions and ammonia molecules are both classed as monodentate ligands.

Explain the term *monodentate*.   **1**

(b) A new drug being trialled, asplatin, is proving to be 10 times more effective than cisplatin.
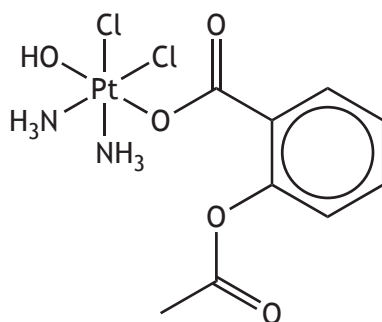
asplatin

11. (b) (continued)

Asplatin is synthesised by reacting oxoplatin with acetylsalicylic anhydride.

oxoplatin	acetylsalicylic anhydride	asplatin
GFM = 334·1 g	GFM = 342·3 g	GFM = 484·1 g
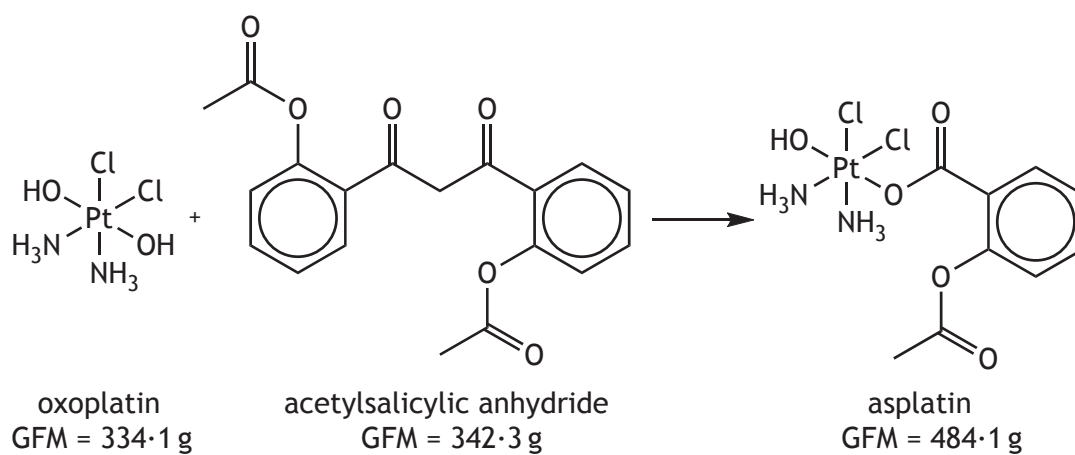
During a trial synthesis, 5·00 g of oxoplatin was reacted with excess acetylsalicylic anhydride to produce 6·36 g of asplatin.

Calculate the percentage yield. **2**

12. Propanoic acid is commonly used in the food industry as a preservative as it can inhibit the growth of mould and bacteria.

Propanoic acid can be prepared from a variety of small molecules. In industry, the main method of production of propanoic acid is by the reaction of ethene with water and carbon monoxide.

$$C_2H_4 \ + \ H_2O \ + \ CO \ \rightarrow \ CH_3CH_2COOH$$

Using your knowledge of chemistry, outline the possible steps in the synthesis of propanoic acid from small molecules such as ethene or ethanol.   **3**

13. Both spectroscopic and chemical analysis can be used to determine the identity of an unknown compound.

The following spectra and chemical data were obtained for a colourless liquid with a pleasant smell.

^{1}H NMR Spectrum

Mass Spectrum

Infra-Red Spectrum
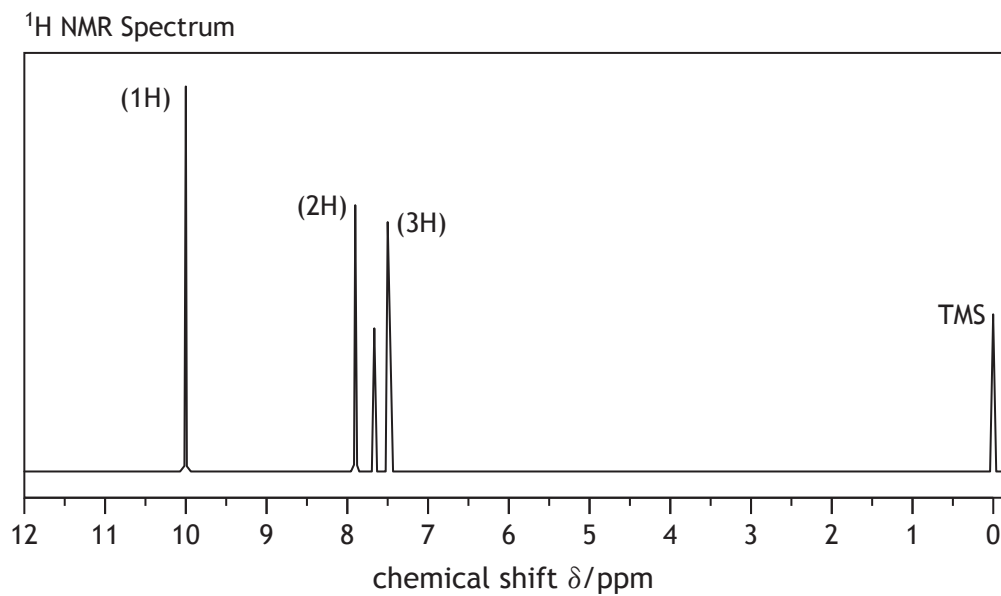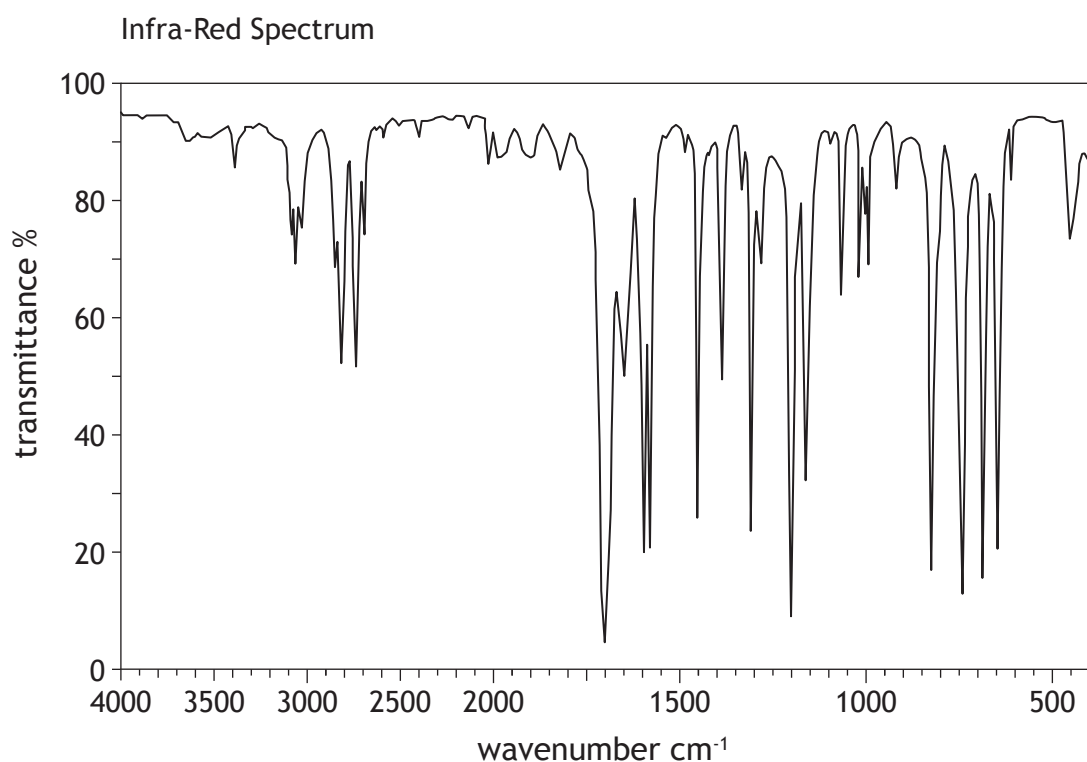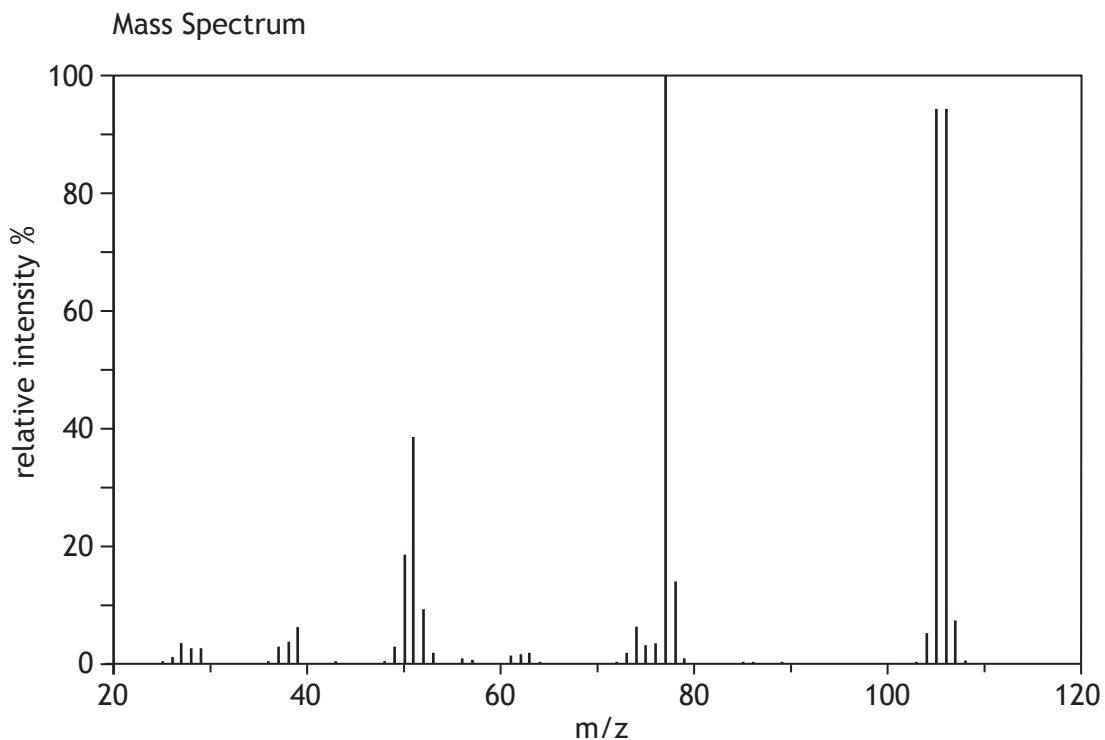
Chemical Data

Composition:	C 79·25%; H 5·66%; O 15·09%
Fehling's/Benedict's:	brick red precipitate forms
Bromine solution:	no change
Aqueous sodium carbonate:	no reaction

13. (continued)

(a) (i) Determine the empirical formula for the compound. **2**

(ii) Using the mass spectrum, determine the molecular formula for the compound. **1**

(b) Identify the functional group in the compound which is responsible for the peak at $1700\,cm^{-1}$ in the infra-red spectrum. **1**

(c) Using all of the information, draw a structural formula for the compound. **1**

[END OF SPECIMEN QUESTION PAPER]

ADDITIONAL SPACE FOR ANSWERS AND ROUGH WORK

ADDITIONAL SPACE FOR ANSWERS AND ROUGH WORK

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Chemistry

Marking Instructions

These Marking Instructions have been provided to show how SQA would mark this Specimen Question Paper.

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General Marking Principles for Advanced Higher Chemistry

This information is provided to help you understand the general principles you must apply when marking candidate responses to questions in this paper. These principles must be read in conjunction with the Detailed Marking Instructions, which identify the key features required in candidate responses.

(a) Marks for each candidate response must <u>always</u> be assigned in line with these General Marking Principles and the Detailed Marking Instructions for this assessment.

(b) Marking should always be positive. This means that, for each candidate response, marks are accumulated for the demonstration of relevant skills, knowledge and understanding: they are not deducted from a maximum on the basis of errors or omissions.

(c) Half marks may not be awarded.

(d) Where a candidate makes an error at an early stage in a multi-stage calculation, credit should normally be given for correct follow-on working in subsequent stages, unless the error significantly reduces the complexity of the remaining stages. The same principle should be applied in questions which require several stages of non-mathematical reasoning. The exception to this rule is where the Marking Instructions for a numerical question assign separate "concept marks" and an "arithmetic mark". In such situations, the Marking Instructions will give clear guidance on the assignment of partial marks.

(e) Unless a numerical question specifically requires evidence of working to be shown, full marks should be awarded for a correct final answer (including units if required) on its own.

(f) Larger mark allocations may be fully accessed whether responses are provided in continuous prose, linked statements or a series of developed bullet points.

(g) Marks should not be deducted for inaccurate or unconventional spelling or vocabulary as long as the meaning of the word(s) is conveyed. **For example,** responses that include "distilling" for "distillation", or "it gets hotter" for "'the temperature rises", should be accepted.

(h) If a correct answer is followed by a wrong answer it should be treated as a cancelling error and no marks should be given. **For example**, in response to the question, "State the colour seen when blue Fehling's solution is warmed with an aldehyde", the answer "red, green" gains no marks.

However, if a correct answer is followed by additional information which does not conflict with that, the additional information should be ignored, whether correct or not. **For example,** in response to a question concerned with melting point, "State why the tube should not be made of copper", the response "Copper has a low melting point and is coloured grey" would **not** be treated as having a cancelling error.

(i) Full marks are usually awarded for the correct answer to a calculation without working and the partial marks shown in the Detailed Marking Instructions are for use when working is given but the final answer is incorrect. An exception is when candidates are asked to "Find, by calculation", when full marks cannot be awarded for the correct answer without working.

(j) Significant figures.
Data in question is given to three significant figures.
Correct final answer is 8·16 J.
Final answer 8·2 J or 8·158 J or 8·1576 J — No penalty.
Final answer 8 J or 8·15761 J — Deduct mark.

Candidates should be penalised for a final answer that includes:
- three or more figures too many

  or

two or more figures too few, **ie accept two more and one fewer**.

(k) Ignore the omission of one H atom from a full structural formula provided the bond is shown.

(l) If a structural formula is asked for, CH_3– and CH_3CH_2 – are acceptable as methyl and ethyl groups respectively.

(m) With structures involving an –OH or an –NH_2 group, mark should only be awarded if the "O" or "N" are bonded to a carbon, ie not OH–CH_2 and NH_2–CH_2.

(n) When drawing structural formulae, mark should only be awarded if the bond points to the "correct" atom. This example would be incorrect.
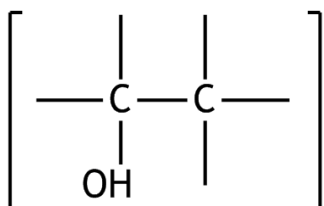
(o) A symbol or correct formula should be accepted in place of a name **unless stated** otherwise in the Detailed Marking Instructions.

(p) When formulae of ionic compounds are given as answers it will only be necessary to show ion charges if these have been specifically asked for. However, if ion charges are shown, they must be correct. If incorrect charges are shown, no marks should be awarded.

(q) If an answer comes directly from the text of the question, no marks should be given.

For example, in response to the question, "A student found that 0·05 mol of propane, C_3H_8 burned to give 82·4 kJ of energy. $C_3H_8(g) + 5O_2(g) \rightarrow 3CO_2(g) + 4H_2O(\ell)$. Name the kind of enthalpy change that the student measured", no marks should be given for "burning" since the word "burned" appears in the text.

(r) A guiding principle in marking is to give credit for correct elements of a response rather than to look for reasons not to give marks. **Example 1:** The structure of a hydrocarbon found in petrol is shown below.

$$CH_3-CH_2-\overset{\overset{\displaystyle CH_3}{|}}{CH}-CH_2-CH_2-CH_3$$
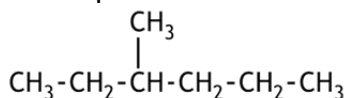
Name the hydrocarbon.

- Although the punctuation is not correct, **"3, methyl-hexane"** should gain the full mark.

Example 2: A student measured the pH of four carboxylic acids to find out how their strength is related to the number of chlorine atoms in the molecule. The results are shown.

Structural formula	pH
CH_3COOH	1·65
$CH_2ClCOOH$	1·27
$CHCl_2COOH$	0·90
CCl_3COOH	0·51

Describe the relationship between the number of chlorine atoms in the molecule and the strength of the acids.

- Although not completely correct, an answer such as "the more Cl$_2$, the stronger the acid" should gain the full mark.

(s) Unless the question is clearly about a non-chemistry issue, eg costs in an industrial chemical process, a non-chemical answer gains no marks.

For example, in response to the question, "Why does the (catalytic) converter have a honeycomb structure?", "to make it work" may be correct but it is not a chemical answer and the mark should not be given.

(t) Marks are awarded only for a valid response to the question asked. For example, in response to questions that ask candidates to:

- **compare**, they must demonstrate knowledge and understanding of the similarities and/or differences between things;
- **complete,** they must finish a chemical equation or fill in a table with information;
- **describe**, they must provide a statement or structure of characteristics and/or features;
- **determine** or **calculate**, they must determine a number from given facts, figures or information;
- **draw,** they must draw a diagram or structural formula**,** eg "Draw a diagram to show the part of a poly(propene) molecule formed from two propene molecules";
- **estimate**, they must determine an approximate value for something;
- **evaluate**, they must make a judgement based on criteria;
- **explain**, they must relate cause and effect and/or make relationships between things clear;
- **identify**, **name**, **give**, or **state**, they need only name or present in brief form;
- **predict**, they must suggest what may happen based on available information;
- **suggest**, they must apply their knowledge and understanding of Chemistry to a new situation. A number of responses are acceptable: marks will be awarded for any suggestions that are supported by knowledge and understanding of Chemistry;
- **use your knowledge of Chemistry or aspect of Chemistry to comment on**, they must apply their skills, knowledge and understanding to respond appropriately to the problem/situation presented (for example by making a statement of principle(s) involved and/or a relationship or equation, and applying these to respond to the problem/situation). They will be rewarded for the breadth and/or depth of their conceptual understanding;
- **write**, they must complete a chemical or word equation, eg write the equation for a given molecule.

Detailed Marking Instructions for each question

SECTION 1
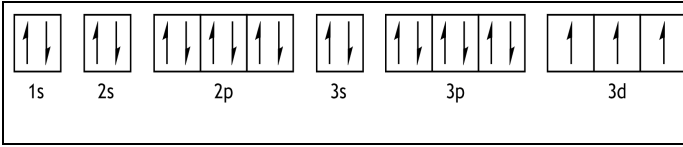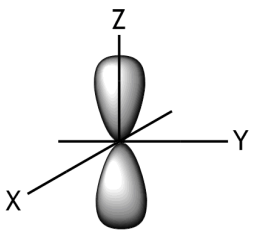
Question	Response	Mark
1	D	1
2	A	1
3	C	1
4	B	1
5	C	1
6	B	1
7	D	1
8	D	1
9	D	1
10	B	1
11	C	1
12	D	1
13	A	1
14	B	1
15	C	1
16	B	1
17	D	1
18	D	1
19	B	1
20	A	1
21	D	1
22	A	1
23	C	1
24	C	1
25	A	1
26	B	1
27	C	1
28	A	1
29	D	1
30	A	1

Question			Expected response	Max mark	Additional guidance
1	a		Lithium	1	
1	b		Energy absorbed resulted in electrons within atoms being promoted to higher energy level. **(1 mark)** When the electron falls back to its original level, energy is emitted in the form of a photon whose wavelength corresponds to red light. **(1 mark)**	2	
1	c		$E = Lhc/(1000) \lambda$ or $= \dfrac{6 \cdot 02 \times 10^{23} \times 6 \cdot 63 \times 10^{-34} \times 3 \times 10^{8}}{670 \cdot 7 \times 10^{-9} \times (1000)}$ **(1 mark)** $= 179 \text{kJ mol}^{-1}$ **(1 mark)**	2	1000 may or may not be included at this step. Significant figure rule applies. Accept 178·53, 178·5 or 180.
2	a		ClO^- (aq), or hypochlorite ion	1	
2	b		$K_a = \dfrac{[H_3O^+][ClO^-]}{[HClO^-]}$	1	allow H^+
2	c		$ClO^-(aq) + H^+(aq) \rightleftharpoons HClO(aq)$ or The H^+(aq) are removed by the conjugate base from the water equilibrium **(1 mark)** and $H_2O(\ell) \rightleftharpoons H^+(aq) + OH^-(aq)$ or This causes the water equilibrium to shift to the right hand side producing excess OH^-(aq) and hence pH>7. or Produces an excess of hydroxide ions. **(1 mark)**	2	State symbols not required.
3			**The whole candidate response should first be read to establish its overall quality in terms of accuracy and relevance to the problem/situation**		This open-ended question requires comment on **why β—carotene is orange.**

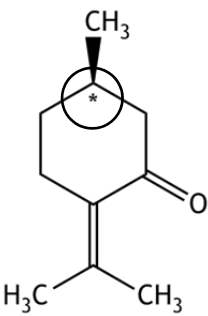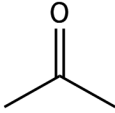| Question			Expected response	Max mark	Additional guidance
			presented. There may be strengths and weaknesses in the candidate response: *assessors should focus as far as possible on the strengths, taking account of weaknesses (errors or omissions) only where they detract from the overall answer in a significant way, which should then be taken into account when determining whether the response demonstrates **reasonable**, **limited** or **no** understanding.* **Assessors should use their professional judgement to apply the guidance below to the wide range of possible candidate responses.**		Candidate responses are expected to make comment on the basis of relevant chemistry ideas/concepts which might include one or more of: talk about conjugation, conjugated systems, chromophores, absorption of light, complementary colours, promotion of electrons, σ and σ^*, π and π^*, longer conjugation tends towards red, HOMO and LUMO.
			3 marks: The candidate has demonstrated a **good** conceptual understanding of the chemistry involved, providing a logically correct response to the problem/situation presented. This type of response might include a statement of principle(s) involved, a relationship or equation, and the application of these to respond to the problem/situation. This does not mean the answer has to be what might be termed an "excellent" answer or a "complete" one.		In response to this question, a **good** understanding might be demonstrated by a candidate response that: • makes comments based on one relevant chemistry idea/concept, in a **detailed/developed** response that is **correct or largely correct** (any weaknesses are minor and do not detract from the overall response) **or** • makes comments based on a range of relevant chemistry ideas/concepts, in a response that is **correct or largely correct** (any weaknesses are minor and do not detract from the overall response) **or** • otherwise demonstrates a good

Question			Expected response	Max mark	Additional guidance
					understanding of the chemistry involved.
			2 marks: The candidate has demonstrated a **reasonable** understanding of the chemistry involved, showing that the problem/situation is understood. This type of response might make some statement(s) that is/are relevant to the problem/situation, for example, a statement of relevant principle(s) or identification of a relevant relationship or equation.		In response to this question, a **reasonable** understanding might be demonstrated by a candidate response that: • makes comments based on one or more relevant chemistry idea(s)/concept(s), in a response that is **largely correc**t but has **weaknesses** which detract to a small extent from the overall response **or** • otherwise demonstrates a reasonable understanding of the chemistry involved.
			1 mark: The candidate has demonstrated a **limited** understanding of the chemistry involved, showing that a little of the chemistry that is relevant to the problem/situation is understood. The candidate has made some statement(s) that is/are relevant to the problem/situation.		In response to this question, a **limited** understanding might be demonstrated by a candidate response that: • makes comments based on one or more relevant chemistry idea(s)/concept(s), in a response that has **weaknesses** which detract to a large extent from the overall response **or** • otherwise demonstrates a limited understanding of the chemistry involved. •
			0 marks: The candidate has demonstrated **no** understanding of the chemistry that is relevant to the problem/situation.	•	• Where the candidate has only demonstrated

Question			Expected response	Max mark	Additional guidance
			The candidate has made no statement(s) that is/are relevant to the problem/situation.		knowledge and understanding of chemistry **that is not relevant to the problem/ situation presented**, 0 marks should be awarded.
4	a	i	+4, 4, 4+ , IV, four.	1	−4, 4− would not be accepted.
	a	ii		1	Box labels not required. Noble gas start accepted in this case. Full or half headed arrows accepted, but not vertical lines. follow through
	a	iii	The three d orbitals are all filled singly (with parallel spins).	1	follow through
	b	i	Degenerate means that the orbitals are of equal energy.	1	
	b	ii	p-orbital	1	axes not necessary any orientation accepted
	c	i	Several solutions of accurate permanganate concentration are made up and the absorbance of each is measured **(1 mark)**. A calibration curve of concentration vs absorbance is drawn**(1 mark)**. The absorbance of the solution of unknown permanganate concentration is measured and the calibration graph is then used to determine the concentration corresponding to this absorbance. **(1 mark)**.	3	

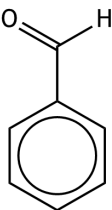| Question			Expected response	Max mark	Additional guidance
	c	ii	$[MnO_4^-] = 4\cdot25 \times 10^{-4}$ mol l^{-1} moles $= 0\cdot25 \times 4\cdot25 \times 10^{-4}$ $\qquad = 1\cdot0625 \times 10^{-4}$ moles moles Mn $= 1\cdot0625 \times 10^{-4}$ moles mass of Mn $= 1\cdot0625 \times 10^{-4} \times 54.9$ **(1 mark)** $\qquad = 5\cdot833 \times 10^{-3}$g % Mn $= 1\cdot7\%$ **(1 mark)**	2	1 mark for concept of 54.9 x calculated moles of manganese. 1 mark for arithmetic. Significant figure rule applies. Accept 2, 1·67, 1·667.
5	a		The mass must be in the region of $0\cdot4$ g and the exact mass must be known.	1	
	b		Pour mixture into standard flask, rinse beaker with distilled water and add rinsings to standard flask. **(1 mark)** and Repeat, mix, make to mark with distilled water. **(1 mark)**	2	
	c	i	low GFM or unstable in air or absorbs moisture or is not a primary standard	1	
	c	ii	Initial moles of HCl $0\cdot02 \times 1 = 0.02$ mol Ave titre = $12\cdot65$ No. moles NaOH = $0\cdot1 \times 0\cdot01265 = 0\cdot001265$ = no. moles HCl left unreacted in 10 cm^3 $10 \times 0\cdot001265 = 0\cdot01265$ in 100 cm^3 **(1 mark)** Moles of acid reacting $0\cdot02 - 0\cdot01265 = 0\cdot00735$ mol **(1 mark)**	4	1 mark concept of the scaling x 10. 1 mark concept of subtraction to calculate moles of acid reacting.

Question			Expected response	Max mark	Additional guidance
			Mass of $CaCO_3$ is (0·00735/2) x 100.1 = 0·3679 g **(1 mark)** %$CaCO_3$ (0·3679/0·390) x 100 = 94.3 % **(1 mark)**		1 mark concept for stoichiometry 2:1. 1 mark for arithmetic. Significant figure rule applies. 94, 94·33, 94·333.
6	a		$C_{17}H_{19}N_3O_3S$	1	Can be given in any order.
	b		A racemate or racemic mixture.	1	
	c		Antagonist	1	
	d	i	In an acidic environment, such as the stomach, the inactive isomer would be converted into the active one. or Cheaper to have a racemic mixture as you don't have to separate enantiomers.	1	
	d	ii	The OH or hydroxyl group.	1	
7	a		$\triangle S = \sum S^0 \text{products} - \sum S^0 \text{reactants}$ = (152 + 2 x 189) – (77 + 4 x 174) 1 mark = (530) – (773) = -243J K^{-1} mol^{-1} **(1 mark)**	2	
	b		$\Delta G^0 = \Delta H^o - T\Delta S^o$ = (-244) – 298(-0.243) **(1 mark)** = (-244) – (-72.414) = -171.6 (kJ mol^{-1}) **(1 mark)** Yes the reaction is feasible. **(1 mark)**	3	Working must be shown. Follow through applies. Units need not be given. Answer in J acceptable.
8	a	i	Solvent extraction.	1	
	a	ii	drain layers into two separate beakers **(1 mark)**	3	

Question			Expected response	Max mark	Additional guidance
			return lower/aqueous layer to separating funnel and add further diethylether and repeat **(1 mark)** evaporation/distillation of all diethylether layers **(1 mark)**		
	a	iii	Immiscible in water. **(1 mark)** Benzocaine soluble in it. **(1 mark)**	2	
	b		recrystallization **or** chromatography **or** glc	1	
	c	i	(Pure) benzocaine	1	
	c	ii	Benzocaine has a small impurity. **or** Any other appropriate answer which suggests the benzocaine is not 100% pure.	1	
9	a	i	2	1	
	a	ii	1	1	
	b		Rate = $k[NO]^2[H_2]$	1	
	c		Using experiment 1, $1.20 \times 10^{-5} = k(4 \times 10^{-3})^2(1 \times 10^{-3})$ $k = \dfrac{1.20 \times 10^{-5}}{(16 \times 10^{-6})(1 \times 10^{-3})}$ $k = 750$ **(1 mark)** $mol^{-2}l^2s^{-1}$ **(1 mark)**	2	

Question			Expected response	Max mark	Additional guidance
10	a			1	
	b		Infra-Red spectroscopy	1	
	c		**(1 mark)** and **(1 mark)**	2	Correct full structural, shortened structural or skeletal formulae can all be accepted.
11	a	i	Cis refers to the geometric isomer where both substituents are on the same "side" of Pt.	1	
		ii	A monodentate ligand forms one dative (covalent) bond (to a central metal atom or ion).	1	
	b		Moles oxoplatin $= \frac{5.00}{334.1} = 1.49656 \times 10^{-2}$ Moles asplatin $= 1.49656 \times 10^{-2}$ Mass asplatin $= 1.49656 \times 10^{-2} \times 484.1$ $\qquad\qquad = 7.245\text{g}$ **(1 mark)** % yield $= \frac{6.36 \, x \, 100}{7.245} = 87.8\ \%$ **(1 mark)**	2	Significant figure rule applies. 88, 87·78, 87·785.

	Question		Expected response	Max mark	Additional guidance
12			**The whole candidate response should first be read to establish its overall quality in terms of accuracy and relevance to the problem/situation presented.** There may be strengths and weaknesses in the candidate response: *assessors should focus as far as possible on the strengths, taking account of weaknesses (errors or omissions) only where they detract from the overall answer in a significant way, which should then be taken into account when determining whether the response demonstrates **reasonable**, **limited** or **no** understanding.* **Assessors should use their professional judgement to apply the guidance below to the wide range of possible candidate responses.**		This open-ended question requires candidates to outline the possible steps in the synthesis of propanoic acid from other small molecules such as ethene or ethanol. Candidate responses are expected to make comment on the basis of relevant chemistry ideas/concepts which might include one or more of: addition reaction, nucleophilic substitution reaction, reduction reaction, oxidation reaction and hydrolysis reaction.
			3 marks: The candidate has demonstrated a **good** conceptual understanding of the chemistry involved, providing a logically correct response to the problem/situation presented. This type of response might include a statement of principle(s) involved, a relationship or equation, and the application of these to respond to the problem/situation. This does not mean the answer has to be what might be termed an "excellent" answer or a "complete" one.		In response to this question, a **good** understanding might be demonstrated by a candidate response that: • makes comments based on one relevant chemistry idea/concept, in a **detailed/developed** response that is **correct or largely correct** (any weaknesses are minor and do not detract from the overall response) **or** • makes comments based on a range of relevant chemistry ideas/concepts, in a response that is **correct or largely correct** (any weaknesses are minor and do not detract from the overall response) **or** • otherwise demonstrates a good understanding of the chemistry involved.

Question			Expected response	Max mark	Additional guidance
			2 marks: The candidate has demonstrated a **reasonable** understanding of the chemistry involved, showing that the problem/situation is understood. This type of response might make some statement(s) that is/are relevant to the problem/situation, for example, a statement of relevant principle(s) or identification of a relevant relationship or equation.		In response to this question, a **reasonable** understanding might be demonstrated by a candidate response that: • makes comments based on one or more relevant chemistry idea(s)/concept(s), in a response that is **largely correc**t but has **weaknesses** which detract to a small extent from the overall response **or** • otherwise demonstrates a reasonable understanding of the chemistry involved.
			1 mark: The candidate has demonstrated a **limited** understanding of the chemistry involved, showing that a little of the chemistry that is relevant to the problem/situation is understood. The candidate has made some statement(s) that is/are relevant to the problem/situation.		In response to this question, a **limited** understanding might be demonstrated by a candidate response that: • makes comments based on one or more relevant chemistry idea(s)/concept(s), in a response that has **weaknesses** which detract to a large extent from the overall response **or** • otherwise demonstrates a limited understanding of the chemistry involved.

Question			Expected response	Max mark	Additional guidance
			0 marks: The candidate has demonstrated **no** understanding of the chemistry that is relevant to the problem/situation. The candidate has made no statement(s) that is/are relevant to the problem/situation.		• Where the candidate has only demonstrated knowledge and understanding of chemistry **that is not relevant to the problem/ situation presented**, 0 marks should be awarded.
13	a	i	Empirical formula C H O 79.25 5.66 15.09 12 1 16 6.60 5.66 0.94 **(1 mark)** 0.94 0.94 0.94 7 : 6 : 1 C_7H_6O **(1 mark)**	2	1 mark for calculating number of moles. 1 mark for formula.
	a	ii	C_7H_6O	1	
	b		C=O or carbonyl group	1	
	c			1	Correct full structural, shortened structural or skeletal formulae can all be accepted. Name is not required.

[END OF SPECIMEN MARKING INSTRUCTIONS]

Page sixteen