This is a Class 1 exam

Lebanon Evangelical School
for Boys and Girls
Loueizeh - Baabda

Stage Exam 02

26MAR2025

Do NOT write in this box. Your MARK will be placed here.

Subject :	A Level : Chemistry 2
Class :	12A
Teacher :	Mrs. Saydeh Nasrallah
Duration :	1 hour

Chemistry Formula sheet

You are to answer the questions to this exam on : This exam paper

Your name :		*Time taken to complete exam*
Your Class :		
Exam Room :		
How many sheets, including cover sheet :		

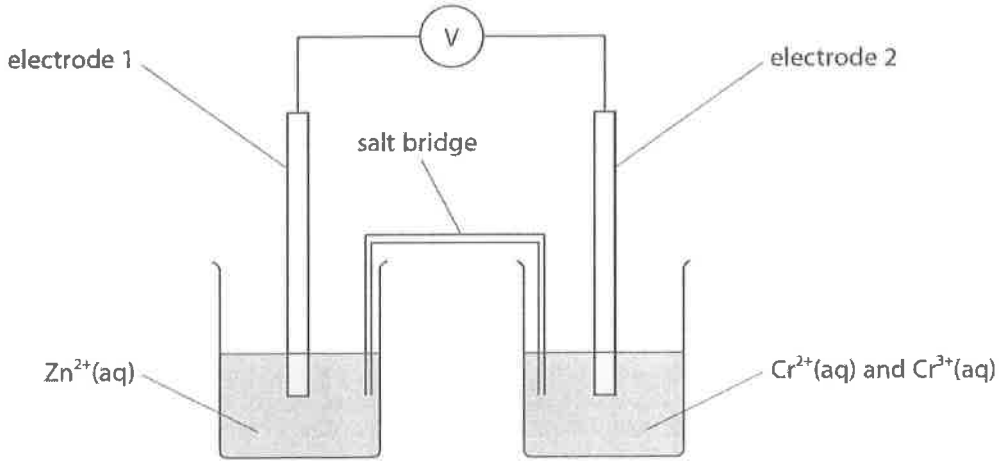
- Do not open this paper until the teacher in charge instructs you to do so.
- The most important thing to remember in taking an exam is NEVER PANIC.
- If you are caught cheating in this exam, you will be awarded zero for ALL exams that are taken on this day.

SECTION A

Answer ALL the questions in this section.
You should aim to spend no more than 20 minutes on this section.
For each question, select one answer from A to D and put a cross in the box.
If you change your mind, put a line through ☒ the box and then mark your new answer with a cross. ☒

1. The apparatus can be used to measure E_{cell} for the reaction shown.

$$2Cr^{3+}(aq) + Zn(s) \rightarrow 2Cr^{2+}(aq) + Zn^{2+}(aq)$$



(a) Which electrodes are used for this cell?

(1)

		Electrode 1	Electrode 2
☐	**A**	Platinum	Platinum
☐	**B**	Platinum	Chromium
☐	**C**	Zinc	Chromium
☐	**D**	Zinc	Platinum

(b) What can be deduced from the fact that, for this reaction, E_{cell} is positive?

(1)

☐ **A** ΔS_{total} and lnK are positive
☐ **B** ΔS_{total} and lnK are negative
☐ **C** ΔS_{total} is positive and lnK is negative
☐ **D** ΔS_{total} is negative and lnK is positive

(Total for Question 1 = 2 marks)

2. Standard electrode potentials can also be given an alternative name.
The electrochemical series lists standard electrode potentials in order. Which of these is correct?

	Alternative name for standard electrode potential	Order of standard electrode potentials in the electrochemical series
☐ **A**	standard reduction potential	most negative to most positive
☐ **B**	standard reduction potential	most positive to most negative
☐ **C**	standard cell potential	most negative to most positive
☐ **D**	standard cell potential	most positive to most negative

(Total for Question 2 = 1 mark)

3. The emf, E_{cell}, of a cell is +0.57 V. The numerical values of the standard electrode potentials of the two half-cells joined in this cell are 0.17 V and 0.40 V.
What are the signs of the standard electrode potentials of the right-hand half-cell and the left-hand half-cell?

	Sign of standard electrode potential	
	in left-hand half-cell	in right-hand half-cell
☐ **A**	negative	negative
☐ **B**	negative	positive
☐ **C**	positive	negative
☐ **D**	positive	positive

(Total for Question 3 = 1 mark)

4. An equation for the reaction of $FeSO_4$ with $KMnO_4$ is shown.

$$2KMnO_4 + 10FeSO_4 + 8H_2SO_4 \rightarrow K_2SO_4 + 2MnSO_4 + 5Fe_2(SO_4)_3 + 8H_2O$$

(a) Which shows the changes in the oxidation states for iron and manganese?

(1)

		Iron	Manganese
☐	**A**	II → III	VII → II
☐	**B**	II → III	VII → IV
☐	**C**	III → II	II → VII
☐	**D**	III → II	III → IV

(b) A 25.00 cm^3 sample of $FeSO_4$ dissolved in acid required 22.50 cm^3 of 0.100 $mol.dm^{-3}$ $KMnO_4$ for complete reaction.
What is the concentration of the $FeSO_4$ solution?

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☐ **A** 0.011 $mol.dm^{-3}$
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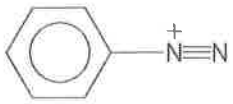
(Total for Question 4 = 2 marks)

5. The emf, $E^{\ominus}_{cell}$, of the cell made up of the **copper** and **magnesium** half-cells is measured under standard conditions.
The voltmeter used has a measurement uncertainty of 0.50%.
What is the highest emf that could be measured in this experiment?
Use your Data Booklet.

☐ **A** 2.70 V
☐ **B** 2.72 V
☐ **C** 2.74 V
☐ **D** 2.85 V

(Total for Question 5 = 1 mark)

6. (a) Which reagents are mixed with hydrochloric acid to produce the benzenediazonium ion?



benzenediazonium ion

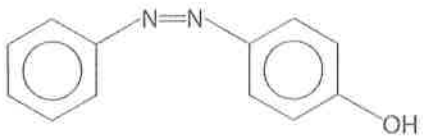
(1)

- ☐ **A** $C_6H_5NH_2$ and $NaNO_2$
- ☒ **B** $C_6H_5NO_2$ and $NaNO_2$
- ☐ **C** $C_6H_5NO_2$ and $NaNO_3$
- ☐ **D** $C_6H_5NH_2$ and $NaNO_3$

(b) Which reagents and conditions are used to prepare the yellow dye 4-phenyldiazenylphenol from the benzenediazonium ion?



benzenediazonium ion



4-phenyldiazenylphenol

(1)

- ☐ **A** phenol dissolved in an acid solution at 25 °C
- ☐ **B** phenol dissolved in an alkaline solution at 25 °C
- ☐ **C** phenol dissolved in an acid solution at 5 °C
- ☐ **D** phenol dissolved in an alkaline solution at 5 °C

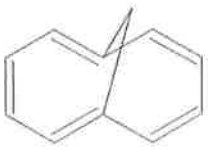
(Total for Question 6 = 2 marks)

7. Which sequence describes recrystallisation?

- ☐ **A** dissolve in the minimum volume of cold solvent, filter to remove the insoluble impurities, then add hot solvent and filter to remove the soluble impurities
- ☐ **B** dissolve in the minimum volume of hot solvent, filter to remove the soluble impurities, wash with cold solvent to remove the insoluble impurities
- ☐ **C** dissolve in the minimum volume of hot solvent, filter to remove the insoluble impurities, then cool and filter to remove the soluble impurities
- ☐ **D** dissolve in the minimum volume of hot solvent, filter to remove the soluble impurities, then cool and filter to remove the insoluble impurities

(Total for Question 7 = 1 mark)

8. An aromatic compound with a ten-carbon ring has the structure shown.



(a) Evidence for the aromaticity of this compound is that the carbon-carbon bonds in the ten-carbon ring

(1)

☐ **A** alternate in length between single and double bonds
☐ **B** all have similar lengths
☒ **C** have no regular pattern of bond length
☐ **D** are all similar to the carbon-carbon double bond length

(b) The aromaticity is due to the formation of pi (π) bonds as a result of overlap of

(1)

☐ **A** s and p orbitals
☐ **B** p and d orbitals
☐ **C** p orbitals
☒ **D** d orbitals

(Total for Question 8 = 2 marks)

TOTAL FOR SECTION A = 12 MARKS

SECTION B

Answer ALL the questions. Write your answers in the spaces provided.

9. Iron is generally prescribed when a person is suffering from anaemia. Many people find it easier to take medicine in liquid form rather than solid tablets.

An iron solution, advertised for this purpose, contains iron as Fe^{2+}.
An adult is advised to take 90.0 mg of iron daily.

A 25.0cm^3 sample of the solution was made up to 100.0cm^3 using sulfuric acid and deionised water.
25.0 cm^3 samples of the diluted iron(II) solution were titrated with a 0.0125 $mol.dm^{-3}$ potassium manganate(VII) solution. The mean titre was 16.20 cm^3.
The reaction is shown.

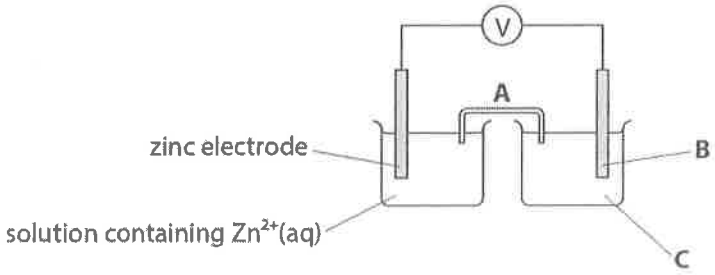
$$MnO_4^- + 8H^+ + 5Fe^{2+} \rightarrow Mn^{2+} + 5Fe^{3+} + 4H_2O$$

Calculate the volume of iron solution required to obtain a 90.0 mg dose of iron.
Give your answer to an appropriate number of significant figures.

Volume required by an adult to obtain a 90.0 mg dose .....cm^3

(Total for Question 9 = 6 marks)

10. The standard emf, $E^{\ominus}_{cell}$, of the cell shown was measured.



Electrode system	Standard electrode potential $E^{\ominus}$/V
$Zn^{2+}(aq) + 2e^- \rightleftharpoons Zn(s)$	−0.76
$Fe^{3+}(aq) + e^- \rightleftharpoons Fe^{2+}(aq)$	+0.77

(a)(i) Identify, by name or formula, the substances needed in the salt bridge and the right-hand half-cell. Include concentrations where appropriate.

(4)

A Salt bridge containing a solution of the compound

.....

.....

B Electrode made of

.....

C Solution containing the compounds

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.....

(ii) State why a salt bridge is used rather than a wire.

(1)

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(b) Write an equation for the reaction that would take place if current was allowed to flow through the circuit. State symbols are not required.

(2)

(c) Under standard conditions, the $E^{\ominus}_{cell}$ for this reaction is +1.53 V.
State what would happen to this value, if anything, when the Zn^{2+} solution in the half-cell is diluted. Justify your answer.

(2)

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(Total for Question 10 = 9 marks)

*11. Compare and contrast the reactions of bromine with benzene and of bromine with cyclohexene.

Consider the types of reaction that occur, the products that form, and any special conditions that may be required.
Justify your answers.

Detailed mechanisms for the reactions are **not** required.

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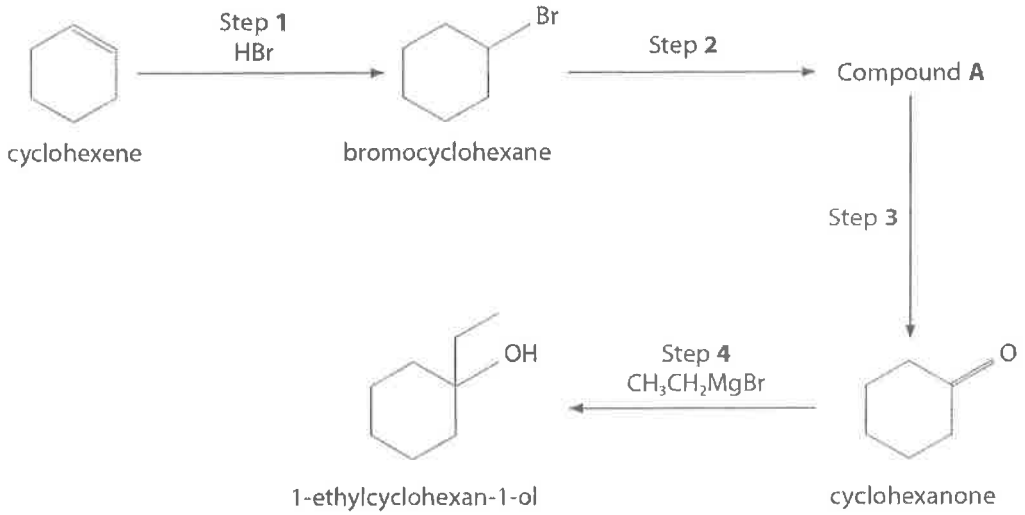
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(Total for Question 11 = 6 marks)

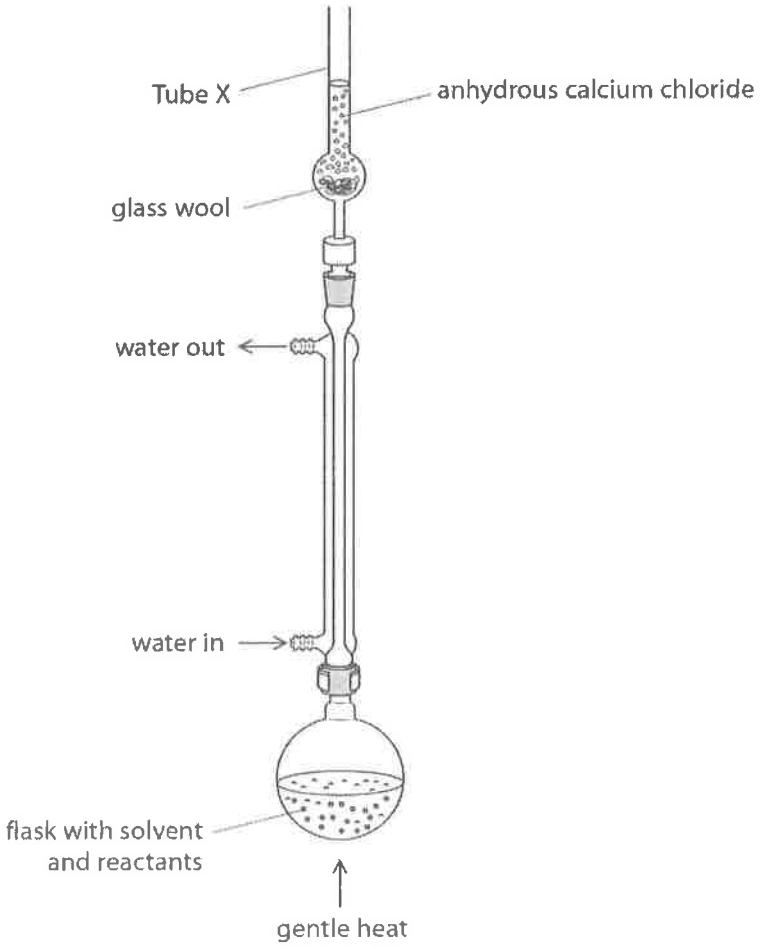
12. The alcohol 1-ethylcyclohexan-1-ol can be synthesised from cyclohexene using the reaction scheme shown.



(a) Devise a reaction scheme for Step **2** and Step **3** of the synthesis.
Include in your answer all reagents and conditions, the type of reaction in each step, and the structure of **A**.

(5)

(b) The reaction to produce the CH_3CH_2MgBr used in Step **4** requires bromoethane and magnesium to be warmed under reflux with a suitable solvent.
The apparatus used for this reaction is shown.



(i) Name the solvent used.

(1)

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(ii) Explain why the anhydrous calcium chloride in Tube **X** is necessary.

(2)

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(iii) Give a reason why it is best practice for the water in the condenser to flow in the direction shown in the diagram.

(1)

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(d) Carbonyl compounds such as cyclohexanone can be identified by the reaction with 2,4-dinitrophenylhydrazine. This reaction is classified as a coupling reaction.

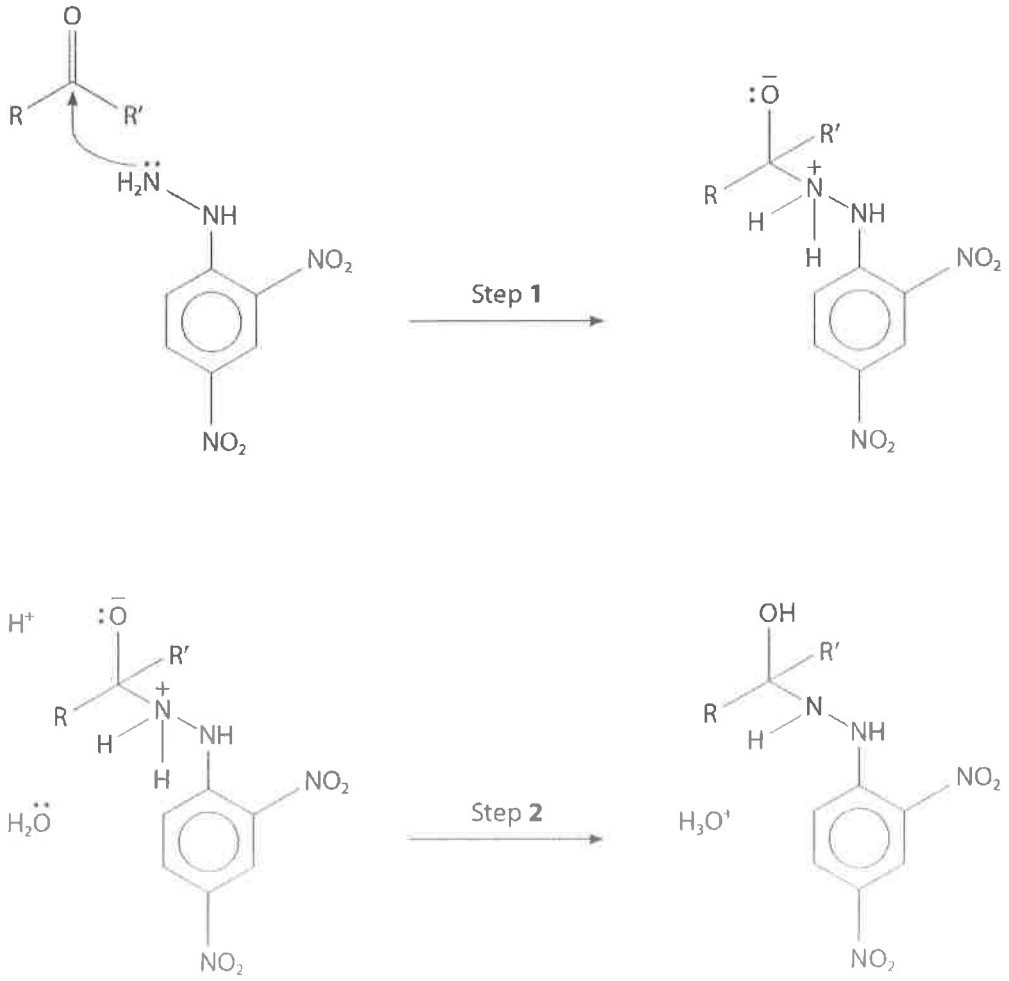
(i) Give the colour of the precipitate formed in this reaction.

(1)

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(ii) Complete the simplified mechanism for the first two steps of the coupling reaction by adding **four** curly arrows.

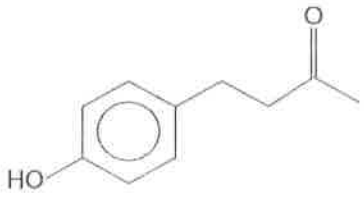
(4)



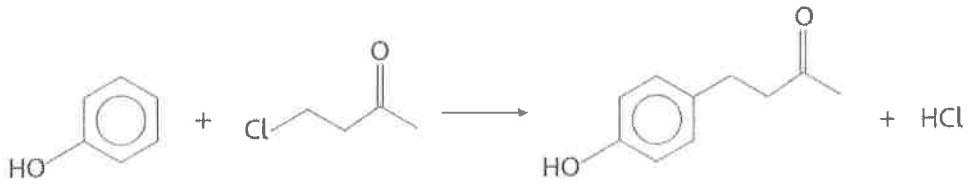
(Total for Question 12 = 14 marks)

13. **Raspberry ketone**

Over two hundred different compounds contribute to the smell of raspberries, including the one known as *raspberry ketone*.



(a) Raspberry ketone can be synthesised in the laboratory from phenol using a Friedel–Crafts reaction. The overall reaction is shown.



(i) Draw the mechanism for this reaction, using appropriate curly arrows.
Include equations showing the formation of the electrophile and the regeneration of the catalyst at the end of the reaction.

(4)

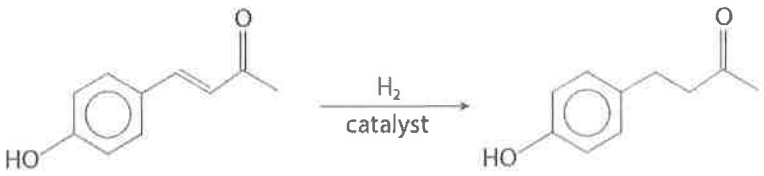
(ii) Give a reason why the yield of the raspberry ketone by this method is **not** high.

(1)

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.....

(b) The second step of the industrial preparation of the raspberry ketone involves the reduction shown.



Suggest why the choice of reducing agent is particularly important in this reaction.

(1)

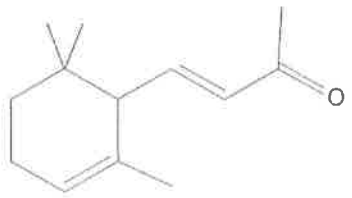
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(c) Two other compounds which contribute to the characteristic smell of raspberries are α-ionone and β-ionone.

(i) Identify with an asterisk (*) the carbon atom environment in α-ionone which would be expected to produce a peak with a **quartet** splitting pattern in a high resolution proton NMR spectrum.

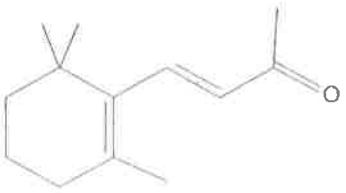
(1)



α-ionone

(ii) Predict the number of peaks in the carbon-13 NMR spectrum of β-ionone, which has the molecular formula $C_{13}H_{20}O$.

(1)



β-ionone

.....

(Total for Question 13 = 8 marks)
TOTAL FOR SECTION B = 43 MARKS
TOTAL FOR PAPER = 55 MARKS

The Periodic Table of Elements

1	2											3	4	5	6	7	0 (8) (18)
							1.0 H hydrogen 1										4.0 He helium 2
(1)	(2)		Key									(13)	(14)	(15)	(16)	(17)	
6.9 Li lithium 3	9.0 Be beryllium 4		relative atomic mass atomic symbol name atomic (proton) number									10.8 B boron 5	12.0 C carbon 6	14.0 N nitrogen 7	16.0 O oxygen 8	19.0 F fluorine 9	20.2 Ne neon 10
23.0 Na sodium 11	24.3 Mg magnesium 12	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	27.0 Al aluminium 13	28.1 Si silicon 14	31.0 P phosphorus 15	32.1 S sulfur 16	35.5 Cl chlorine 17	39.9 Ar argon 18
39.1 K potassium 19	40.1 Ca calcium 20	45.0 Sc scandium 21	47.9 Ti titanium 22	50.9 V vanadium 23	52.0 Cr chromium 24	54.9 Mn manganese 25	55.8 Fe iron 26	58.9 Co cobalt 27	58.7 Ni nickel 28	63.5 Cu copper 29	65.4 Zn zinc 30	69.7 Ga gallium 31	72.6 Ge germanium 32	74.9 As arsenic 33	79.0 Se selenium 34	79.9 Br bromine 35	83.8 Kr krypton 36
85.5 Rb rubidium 37	87.6 Sr strontium 38	88.9 Y yttrium 39	91.2 Zr zirconium 40	92.9 Nb niobium 41	95.9 Mo molybdenum 42	[98] Tc technetium 43	101.1 Ru ruthenium 44	102.9 Rh rhodium 45	106.4 Pd palladium 46	107.9 Ag silver 47	112.4 Cd cadmium 48	114.8 In indium 49	118.7 Sn tin 50	121.8 Sb antimony 51	127.6 Te tellurium 52	126.9 I iodine 53	131.3 Xe xenon 54
132.9 Cs caesium 55	137.3 Ba barium 56	138.9 La* lanthanum 57	178.5 Hf hafnium 72	180.9 Ta tantalum 73	183.8 W tungsten 74	186.2 Re rhenium 75	190.2 Os osmium 76	192.2 Ir iridium 77	195.1 Pt platinum 78	197.0 Au gold 79	200.6 Hg mercury 80	204.4 Tl thallium 81	207.2 Pb lead 82	209.0 Bi bismuth 83	[209] Po polonium 84	[210] At astatine 85	[222] Rn radon 86
[223] Fr francium 87	[226] Ra radium 88	[227] Ac* actinium 89	[261] Rf rutherfordium 104	[262] Db dubnium 105	[266] Sg seaborgium 106	[264] Bh bohrium 107	[277] Hs hassium 108	[268] Mt meitnerium 109	[271] Ds darmstadtium 110	[272] Rg roentgenium 111							

Elements with atomic numbers 112-116 have been reported but not fully authenticated

140 Ce cerium 58	141 Pr praseodymium 59	144 Nd neodymium 60	[147] Pm promethium 61	150 Sm samarium 62	152 Eu europium 63	157 Gd gadolinium 64	159 Tb terbium 65	163 Dy dysprosium 66	165 Ho holmium 67	167 Er erbium 68	169 Tm thulium 69	173 Yb ytterbium 70	175 Lu lutetium 71
232 Th thorium 90	[231] Pa protactinium 91	238 U uranium 92	[237] Np neptunium 93	[242] Pu plutonium 94	[243] Am americium 95	[247] Cm curium 96	[245] Bk berkelium 97	[251] Cf californium 98	[254] Es einsteinium 99	[253] Fm fermium 100	[256] Md mendelevium 101	[254] No nobelium 102	[257] Lr lawrencium 103

* Lanthanide series

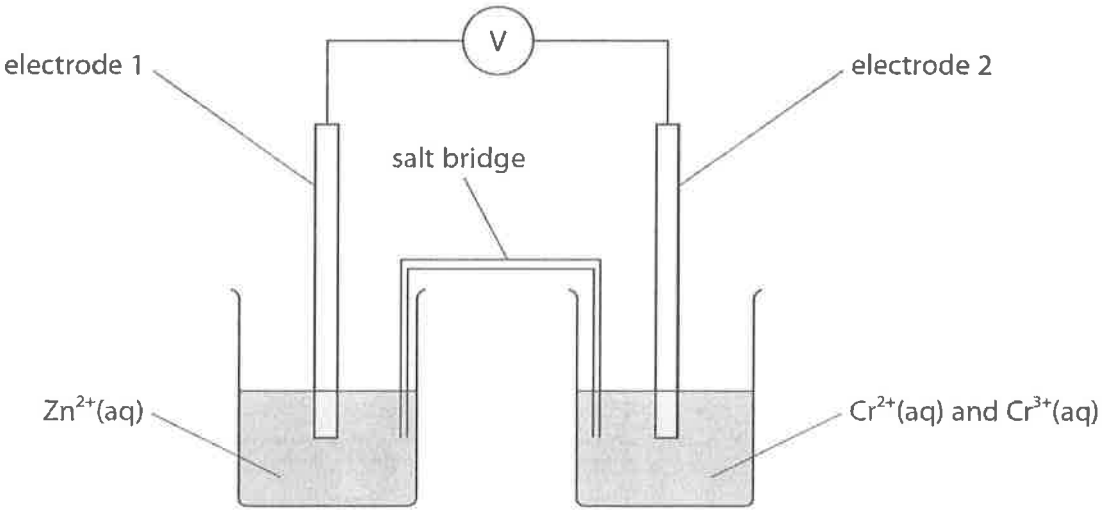
* Actinide series

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(b) What can be deduced from the fact that, for this reaction, E_{cell} is positive?

(1)

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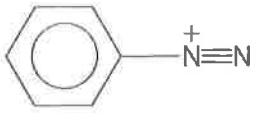
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☒ **B** 2.72 V
☐ **C** 2.74 V
☐ **D** 2.85 V

(Total for Question 5 = 1 mark)

6. (a) Which reagents are mixed with hydrochloric acid to produce the benzenediazonium ion?

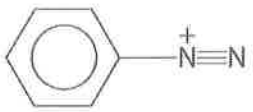


benzenediazonium ion

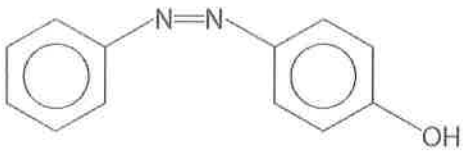
(1)

- ☒ **A** $C_6H_5NH_2$ and $NaNO_2$
- ☒ **B** $C_6H_5NO_2$ and $NaNO_2$
- ☒ **C** $C_6H_5NO_2$ and $NaNO_3$
- ☒ **D** $C_6H_5NH_2$ and $NaNO_3$

(b) Which reagents and conditions are used to prepare the yellow dye 4-phenyldiazenylphenol from the benzenediazonium ion?



benzenediazonium ion



4-phenyldiazenylphenol

(1)

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- ☒ **C** phenol dissolved in an acid solution at 5 °C
- ☒ **D** phenol dissolved in an alkaline solution at 5 °C

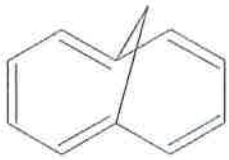
(Total for Question 6 = 2 marks)

7. Which sequence describes recrystallisation?

- ☒ **A** dissolve in the minimum volume of cold solvent, filter to remove the insoluble impurities, then add hot solvent and filter to remove the soluble impurities
- ☒ **B** dissolve in the minimum volume of hot solvent, filter to remove the soluble impurities, wash with cold solvent to remove the insoluble impurities
- ☒ **C** dissolve in the minimum volume of hot solvent, filter to remove the insoluble impurities, then cool and filter to remove the soluble impurities
- ☒ **D** dissolve in the minimum volume of hot solvent, filter to remove the soluble impurities, then cool and filter to remove the insoluble impurities

(Total for Question 7 = 1 mark)

8. An aromatic compound with a ten-carbon ring has the structure shown.



(a) Evidence for the aromaticity of this compound is that the carbon-carbon bonds in the ten-carbon ring

(1)

- ☒ **A** alternate in length between single and double bonds
- ☒ **B** all have similar lengths
- ☒ **C** have no regular pattern of bond length
- ☒ **D** are all similar to the carbon-carbon double bond length

(b) The aromaticity is due to the formation of pi (π) bonds as a result of overlap of

(1)

- ☐ **A** s and p orbitals
- ☐ **B** p and d orbitals
- ☒ **C** p orbitals
- ☐ **D** d orbitals

(Total for Question 8 = 2 marks)

TOTAL FOR SECTION A = 12 MARKS

SECTION B

Answer ALL the questions. Write your answers in the spaces provided.

9. Iron is generally prescribed when a person is suffering from anaemia. Many people find it easier to take medicine in liquid form rather than solid tablets.

An iron solution, advertised for this purpose, contains iron as Fe^{2+}.
An adult is advised to take 90.0 mg of iron daily.

A 25.0cm^3 sample of the solution was made up to 100.0cm^3 using sulfuric acid and deionised water.
25.0 cm^3 samples of the diluted iron(II) solution were titrated with a 0.0125 mol.dm^{-3} potassium manganate(VII) solution. The mean titre was 16.20 cm^3.
The reaction is shown.

$$MnO_4^- + 8H^+ + 5Fe^{2+} \rightarrow Mn^{2+} + 5Fe^{3+} + 4H_2O$$

Calculate the volume of iron solution required to obtain a 90.0 mg dose of iron.
Give your answer to an appropriate number of significant figures.

$n_{Fe^{2+}} = 5 \times n_{MnO_4^-}$ (1)

$= 5 \times 0.0125 \times 16.20 \times 10^{-3} = 1.0125 \times 10^{-3}$ mol (1)

$n_{Fe^{2+}}(\text{diluted}) = n_{Fe^{2+}}(\text{original solution}) = 4 \times 1.0125 \times 10^{-3}$

$= 4.05 \times 10^{-3}$ mol (1)

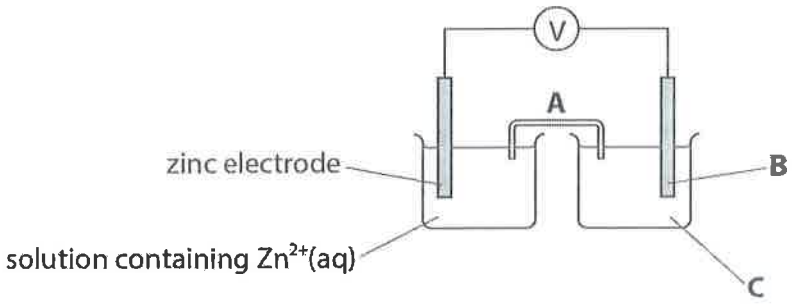
$\Rightarrow m_{Fe^{2+}}(25\,cm^3 \text{ sample}) = 4.05 \times 10^{-3} \times 55.8 = 225.99$ mg (1)

$\Rightarrow \frac{V_{solution}}{90} = \frac{25}{225.99} \Rightarrow V_{required} = 9.96\ cm^3$ (1)

Volume required by an adult to obtain a 90.0 mg dose ....10.0.... cm^3 (1)

(Total for Question 9 = 6 marks)

10. The standard emf, $E^{\ominus}_{cell}$, of the cell shown was measured.



Electrode system	Standard electrode potential $E^{\ominus}$/V
$Zn^{2+}(aq) + 2e^- \rightleftharpoons Zn(s)$	−0.76
$Fe^{3+}(aq) + e^- \rightleftharpoons Fe^{2+}(aq)$	+0.77

(a)(i) Identify, by name or formula, the substances needed in the salt bridge and the right-hand half-cell. Include concentrations where appropriate.

(4)

A Salt bridge containing a solution of the compound

KNO_3 / potassium nitrate (1)

B Electrode made of

Platinum (1)

C Solution containing the compounds

$[Fe^{2+}] = [Fe^{3+}] = 1\ mol.dm^{-3}$ (1) (1)

$Fe(NO_3)_2$ & $Fe(NO_3)_3$ solutions

(ii) State why a salt bridge is used rather than a wire.

(1)

To allow the migration of ion into the half-cells. (1)

(b) Write an equation for the reaction that would take place if current was allowed to flow through the circuit. State symbols are not required.

(2)

$2Fe^{3+} + Zn \longrightarrow 2Fe^{2+} + Zn^{2+}$ (2)

(c) Under standard conditions, the E°_{cell} for this reaction is +1.53 V.
State what would happen to this value, if anything, when the Zn^{2+} solution in the half-cell is diluted. Justify your answer.

(2)

If $[Zn^{2+}] < 1\ mol.dm^{-3}$, then the eqm $Zn^{2+}_{(aq)} + 2e^- \rightleftharpoons Zn_{(s)}$ would shift in the backward direction causing the electrode potential to become more negative (1)

But ; e.m.f = $E^{\ominus}_{red} - E_{ox}$

and $E_{ox} < E^{\ominus}_{ox}$

hence emf would increase and thus becomes greater than 1.53 V (1)

(Total for Question 10 = 9 marks)

*11. Compare and contrast the reactions of bromine with benzene and of bromine with cyclohexene.

Consider the types of reaction that occur, the products that form, and any special conditions that may be required.
Justify your answers.

Detailed mechanisms for the reactions are **not** required.

Benzene unlike any other alkene undergoes substitution whereas alkenes undergo addition. ✓ (1)

The π ring in benzene same as the π bond in alkene is rich in e^-, and hence attract electrophiles. ✓ (1)

But the 6 π e^- give benzene a great stability compared to alkene, where the lengths and strengths of its bonds are different than in alkene which causes the reaction of benzene have a high E_a. ✓ (1)

To overcome this high E_a a halogen carrier is added to catalyse the bromination of benzene.

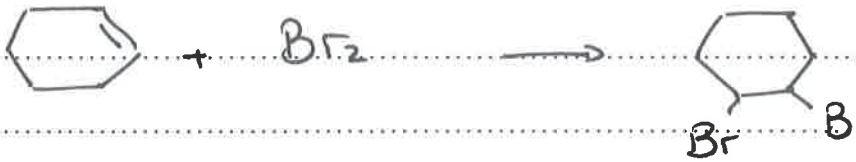
This isn't the case with cyclohexene, where the reaction requires no catalyst to be present. ✓ (1)

With benzene, a monosubstituted compound is produced, and the π ring in benzene is still present in the product. ✓

$C_6H_6 + Br_2 \xrightarrow{FeCl_3} C_6H_5Br + HBr$ (1)



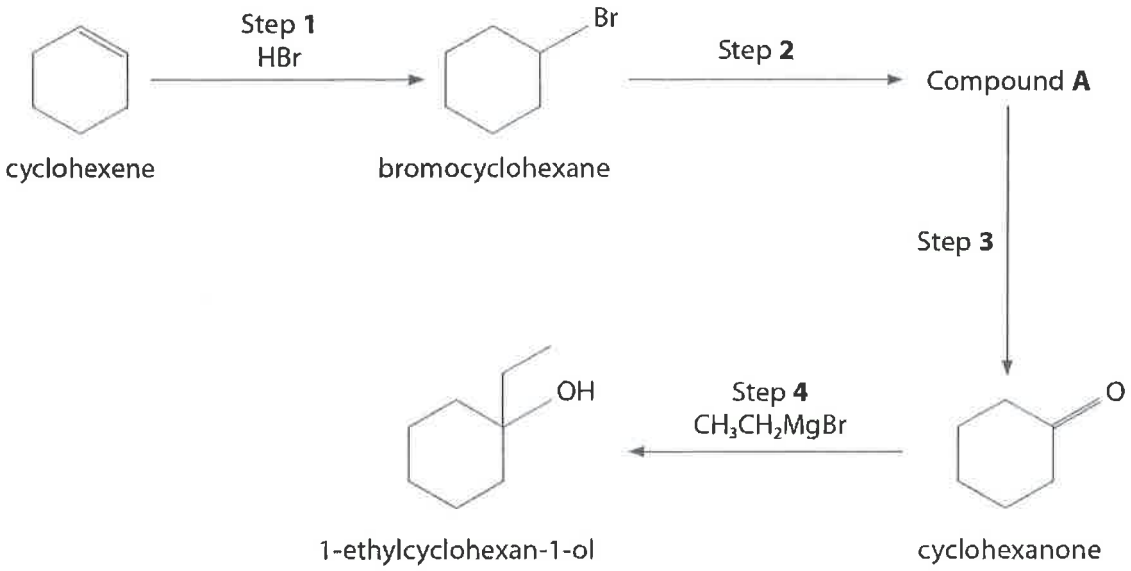
Whereas with cyclohexene, a disubstituted cycloalkane is produced. All bonds are σ bonds. ✓



(1)

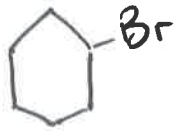
(Total for Question 11 = 6 marks)

12. The alcohol 1-ethylcyclohexan-1-ol can be synthesised from cyclohexene using the reaction scheme shown.

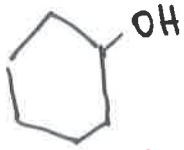


(a) Devise a reaction scheme for Step **2** and Step **3** of the synthesis.
Include in your answer all reagents and conditions, the type of reaction in each step, and the structure of **A**.

(5)

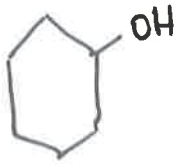


KOH (aq)
heat under reflux

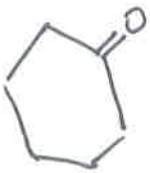


: compound A

Nucleophilic substitution reaction

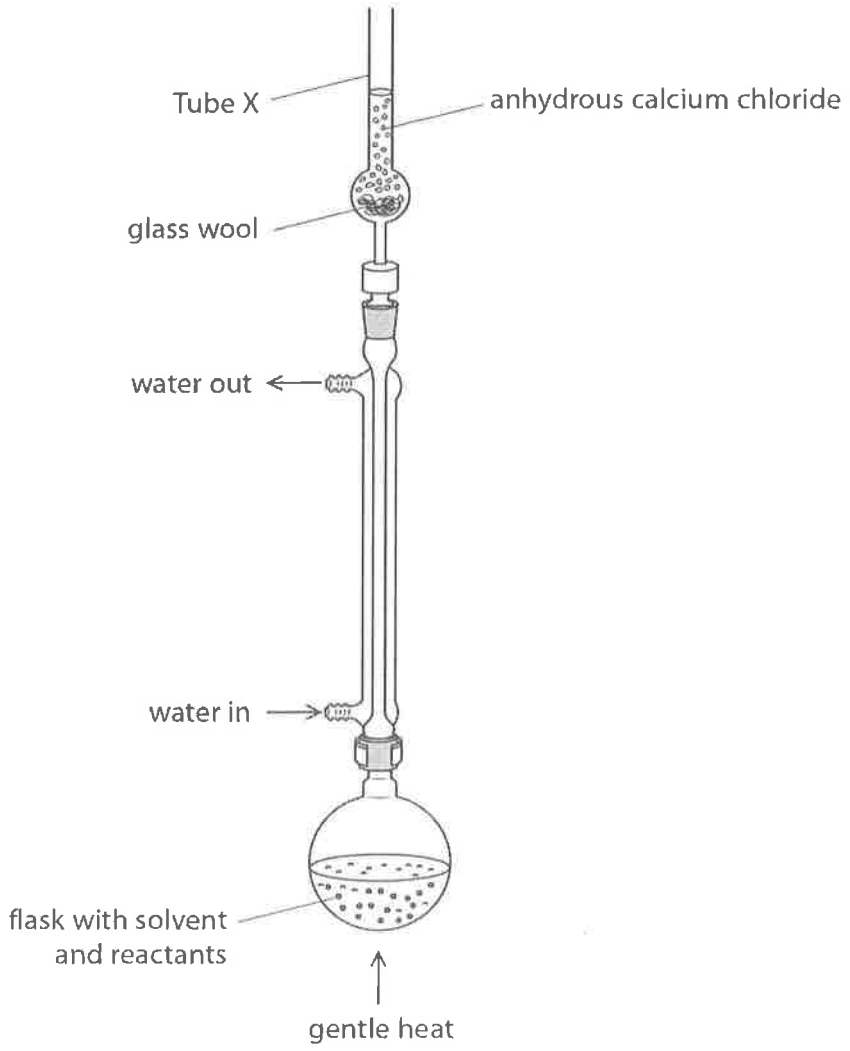


$K_2Cr_2O_7$ / H_2SO_4 (dil)
heat under reflux



Redox reaction

(b) The reaction to produce the CH_3CH_2MgBr used in Step **4** requires bromoethane and magnesium to be warmed under reflux with a suitable solvent.
The apparatus used for this reaction is shown.



(i) Name the solvent used.

Dry ethyl ether ✓ (1) (1)

(ii) Explain why the anhydrous calcium chloride in Tube **X** is necessary.

(2)

Anhydrous calcium chloride is used to absorb the atmospheric humidity (1) and hence keeping the solvent dry and (1) preventing the hydrolysis of the Grignard reagent

(iii) Give a reason why it is best practice for the water in the condenser to flow in the direction shown in the diagram.

(1)

To ensure a uniform cooling of the condenser ✓ (1)

(d) Carbonyl compounds such as cyclohexanone can be identified by the reaction with 2,4-dinitrophenylhydrazine. This reaction is classified as a coupling reaction.

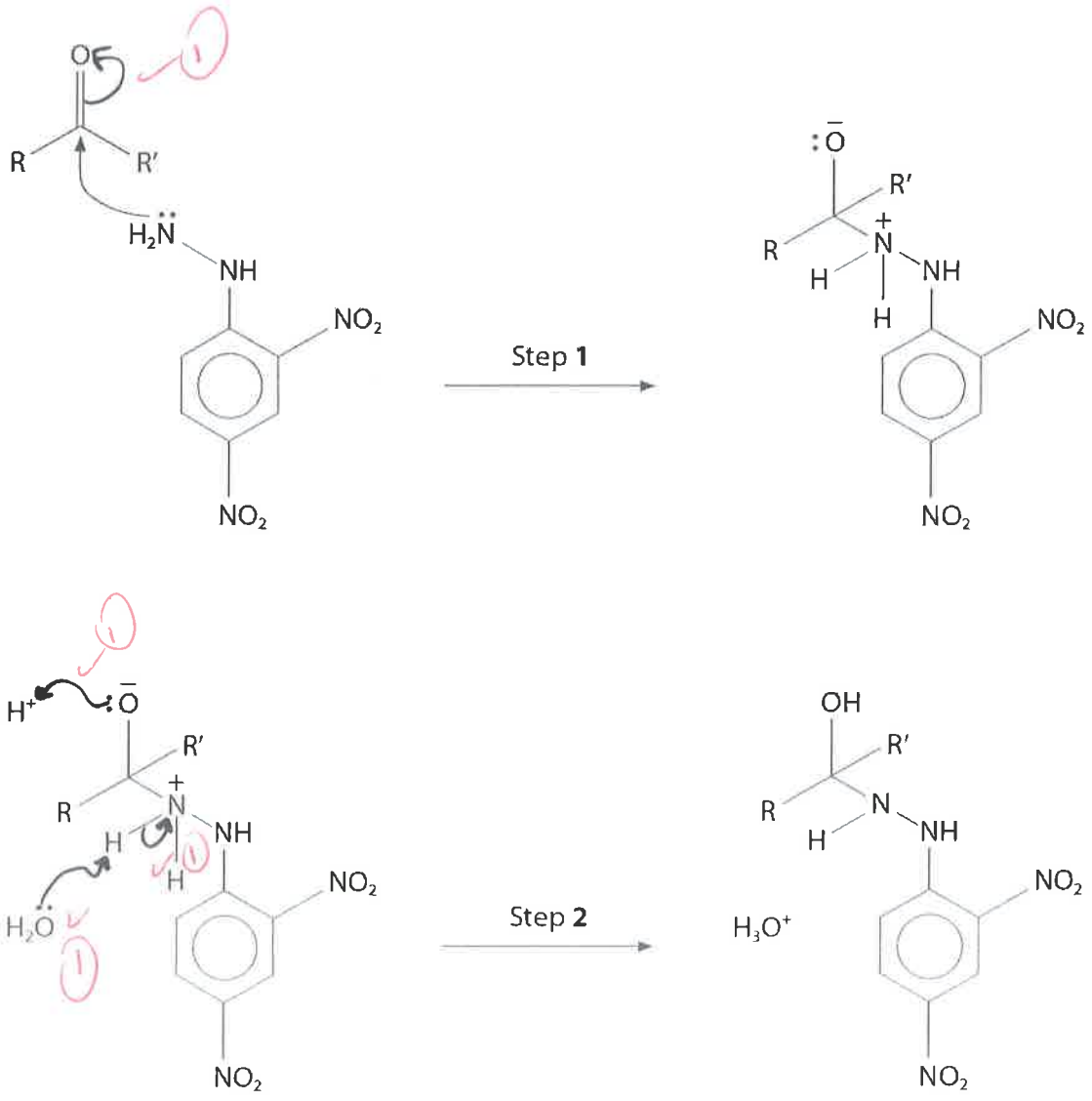
(i) Give the colour of the precipitate formed in this reaction.

(1)

Orange ✓ (1)

(ii) Complete the simplified mechanism for the first two steps of the coupling reaction by adding **four** curly arrows.

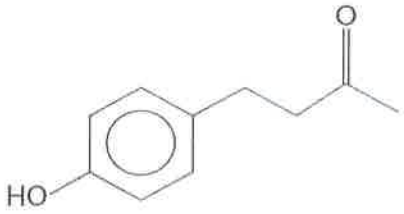
(4)



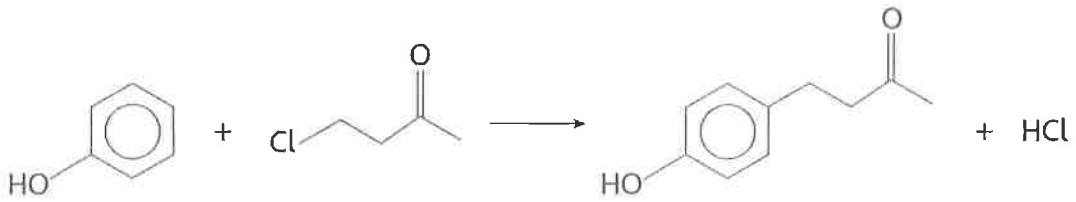
(Total for Question 12 = 14 marks)

13. **Raspberry ketone**

Over two hundred different compounds contribute to the smell of raspberries, including the one known as *raspberry ketone*.

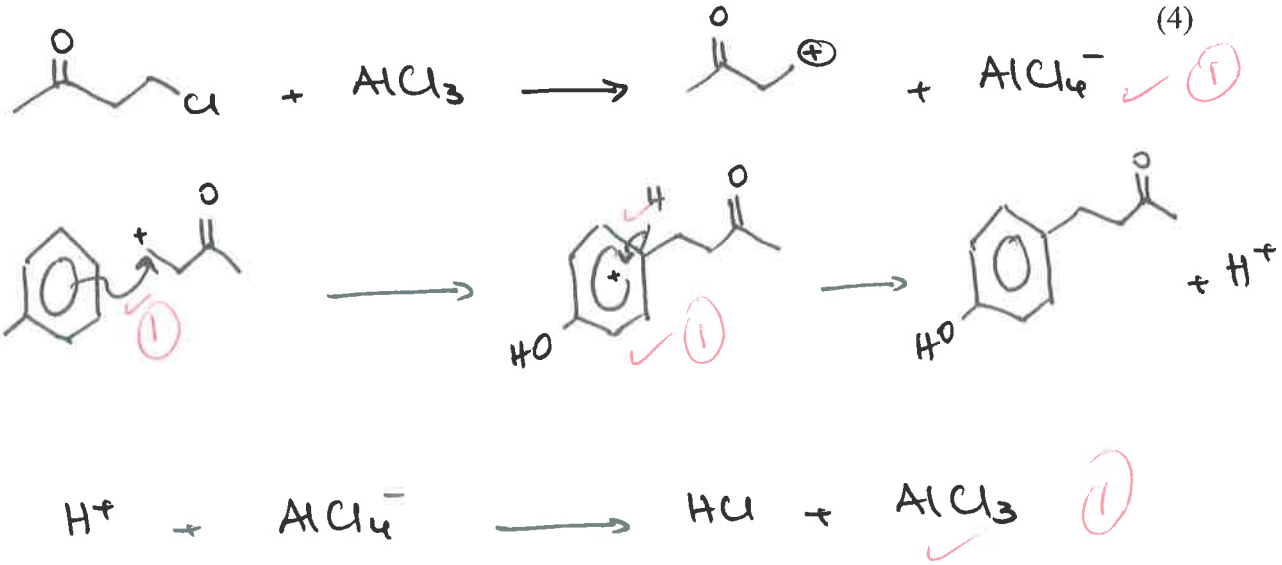


(a) Raspberry ketone can be synthesised in the laboratory from phenol using a Friedel–Crafts reaction. The overall reaction is shown.



(i) Draw the mechanism for this reaction, using appropriate curly arrows.
Include equations showing the formation of the electrophile and the regeneration of the catalyst at the end of the reaction.

(4)

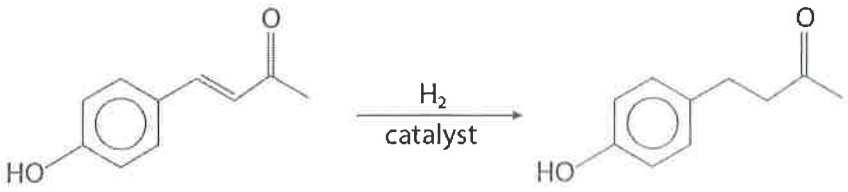


(ii) Give a reason why the yield of the raspberry ketone by this method is **not** high.

(1)

The substitution isn't only directed in the para position ✓ (1)

(b) The second step of the industrial preparation of the raspberry ketone involves the reduction shown.



Suggest why the choice of reducing agent is particularly important in this reaction.

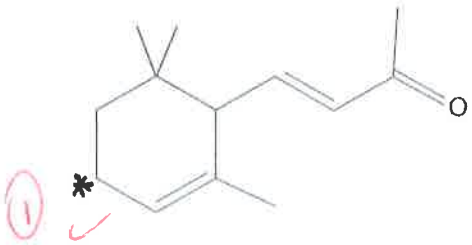
(1)

To prevent the reduction of the ketone functional group ✓(1)

(c) Two other compounds which contribute to the characteristic smell of raspberries are α-ionone and β-ionone.

(i) Identify with an asterisk (*) the carbon atom environment in α-ionone which would be expected to produce a peak with a **quartet** splitting pattern in a high resolution proton NMR spectrum.

(1)

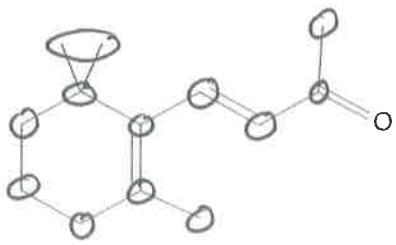


(1) ✓

α-ionone

(ii) Predict the number of peaks in the carbon-13 NMR spectrum of β-ionone, which has the molecular formula $C_{13}H_{20}O$.

(1)



β-ionone

12 peaks ✓(1)

(Total for Question 13 = 8 marks)
TOTAL FOR SECTION B = 43 MARKS
TOTAL FOR PAPER = 55 MARKS

The Periodic Table of Elements

1	2											3	4	5	6	7	0 (8) (18)
							1.0 H hydrogen 1										4.0 He helium 2
(1)	(2)		Key									(13)	(14)	(15)	(16)	(17)	
6.9 Li lithium 3	9.0 Be beryllium 4		relative atomic mass atomic symbol name atomic (proton) number									10.8 B boron 5	12.0 C carbon 6	14.0 N nitrogen 7	16.0 O oxygen 8	19.0 F fluorine 9	20.2 Ne neon 10
23.0 Na sodium 11	24.3 Mg magnesium 12	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	27.0 Al aluminium 13	28.1 Si silicon 14	31.0 P phosphorus 15	32.1 S sulfur 16	35.5 Cl chlorine 17	39.9 Ar argon 18
39.1 K potassium 19	40.1 Ca calcium 20	45.0 Sc scandium 21	47.9 Ti titanium 22	50.9 V vanadium 23	52.0 Cr chromium 24	54.9 Mn manganese 25	55.8 Fe iron 26	58.9 Co cobalt 27	58.7 Ni nickel 28	63.5 Cu copper 29	65.4 Zn zinc 30	69.7 Ga gallium 31	72.6 Ge germanium 32	74.9 As arsenic 33	79.0 Se selenium 34	79.9 Br bromine 35	83.8 Kr krypton 36
85.5 Rb rubidium 37	87.6 Sr strontium 38	88.9 Y yttrium 39	91.2 Zr zirconium 40	92.9 Nb niobium 41	95.9 Mo molybdenum 42	[98] Tc technetium 43	101.1 Ru ruthenium 44	102.9 Rh rhodium 45	106.4 Pd palladium 46	107.9 Ag silver 47	112.4 Cd cadmium 48	114.8 In indium 49	118.7 Sn tin 50	121.8 Sb antimony 51	127.6 Te tellurium 52	126.9 I iodine 53	131.3 Xe xenon 54
132.9 Cs caesium 55	137.3 Ba barium 56	138.9 La* lanthanum 57	178.5 Hf hafnium 72	180.9 Ta tantalum 73	183.8 W tungsten 74	186.2 Re rhenium 75	190.2 Os osmium 76	192.2 Ir iridium 77	195.1 Pt platinum 78	197.0 Au gold 79	200.6 Hg mercury 80	204.4 Tl thallium 81	207.2 Pb lead 82	209.0 Bi bismuth 83	[209] Po polonium 84	[210] At astatine 85	[222] Rn radon 86
[223] Fr francium 87	[226] Ra radium 88	[227] Ac* actinium 89	[261] Rf rutherfordium 104	[262] Db dubnium 105	[266] Sg seaborgium 106	[264] Bh bohrium 107	[277] Hs hassium 108	[268] Mt meitnerium 109	[271] Ds darmstadtium 110	[272] Rg roentgenium 111							

Elements with atomic numbers 112-116 have been reported but not fully authenticated

* Lanthanide series	140 Ce cerium 58	141 Pr praseodymium 59	144 Nd neodymium 60	[147] Pm promethium 61	150 Sm samarium 62	152 Eu europium 63	157 Gd gadolinium 64	159 Tb terbium 65	163 Dy dysprosium 66	165 Ho holmium 67	167 Er erbium 68	169 Tm thulium 69	173 Yb ytterbium 70	175 Lu lutetium 71
* Actinide series	232 Th thorium 90	[231] Pa protactinium 91	238 U uranium 92	[237] Np neptunium 93	[242] Pu plutonium 94	[243] Am americium 95	[247] Cm curium 96	[245] Bk berkelium 97	[251] Cf californium 98	[254] Es einsteinium 99	[253] Fm fermium 100	[256] Md mendelevium 101	[254] No nobelium 102	[257] Lr lawrencium 103