OCR
Oxford Cambridge and RSA

Tuesday 06 October 2020 – Afternoon

A Level Chemistry B (Salters)

H433/01 Fundamentals of Chemistry

Time allowed: 2 hours 15 minutes

You must have:
- the Data Sheet for Chemistry B

You can use:
- a scientific or graphical calculator
- an HB pencil

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H433/01

Please write clearly in black ink. **Do not write in the barcodes.**

Centre number | | | | | | Candidate number | | | | |

First name(s) _____

Last name _____

INSTRUCTIONS
- Use black ink. You can use an HB pencil, but only for graphs and diagrams.
- Write your answer to each question in the space provided. If you need extra space use the lined pages at the end of this booklet. The question numbers must be clearly shown.
- Answer **all** the questions.
- Where appropriate, your answer should be supported with working. Marks might be given for using a correct method, even if your answer is wrong.

INFORMATION
- The total mark for this paper is **110**.
- The marks for each question are shown in brackets **[ ]**.
- Quality of extended response will be assessed in questions marked with an asterisk (*).
- This document has **32** pages.

ADVICE
- Read each question carefully before you start your answer.

SECTION A

You should spend a maximum of 40 minutes on this section.

Answer **all** the questions.

Write your answer to each question in the box provided.

1 Which statement about electromagnetic radiation is correct?

A Infrared radiation has a shorter wavelength than visible light.

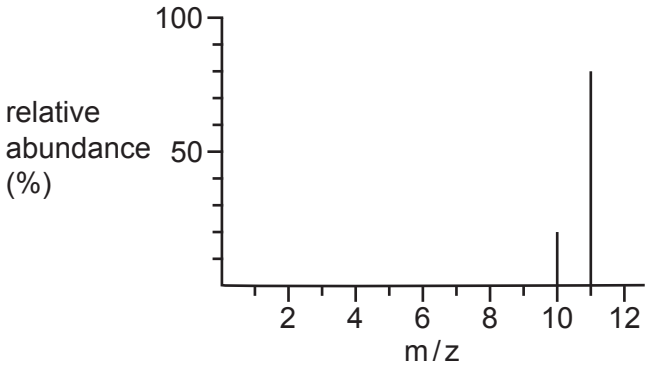
B The frequency of infrared radiation is higher than visible light.

C Infrared and ultraviolet radiation travel at the same speed.

D Visible light has a higher frequency than ultraviolet radiation.

Your answer ☐ **[1]**

2 The mass spectrum of a sample of an element is shown below.



What is the relative atomic mass of the element?

A 10.5

B 10.8

C 11.0

D 13.3

Your answer ☐ **[1]**

3 What provided evidence of the atomic nucleus?

A Thomson's discovery that all elements contain electrons.

B Geiger and Marsden firing α-particles at gold leaf.

C The magnitude of successive ionisation energies.

D The lines on an atomic emission spectrum.

Your answer ☐ **[1]**

4 Reversible reactions reach dynamic equilibrium.

What is correct about these equilibria?

A They must be set up in a closed system.

B The overall concentrations remain constant because molecules have stopped reacting.

C The rates of the forward and reverse reactions are zero.

D The position of equilibrium is always independent of temperature.

Your answer ☐ **[1]**

5 What is the functional group in $C_6H_5COCH_3$?

A Aldehyde

B Carboxylic acid

C Ester

D Ketone

Your answer ☐ **[1]**

6 Which row shows the correct pollutants produced when burning the fuel?

	Fuel	Sulfur dioxide	Carbon monoxide	Particulates	Oxides of nitrogen
A	Biodiesel	✗	✓	✓	✗
B	Ethanol	✓	✗	✗	✓
C	Hydrogen	✗	✗	✗	✓
D	Petrol	✓	✗	✓	✓

Your answer ☐ **[1]**

7 What causes an enhanced greenhouse effect?

A Less ozone in the ozone layer

B Less UV from the Sun

C More methane in the troposphere

D More ozone in the troposphere

Your answer ☐ **[1]**

8 Which ion would have a coloured chloride?

A Cu^{+}

B Sc^{3+}

C Ti^{3+}

D Zn^{2+}

Your answer ☐ **[1]**

9 Which statement about gas-liquid chromatography is correct?

A The column consists of a low boiling liquid on a porous support.

B The compound with the longest retention time comes out first.

C The emerging compounds can be detected by mass spectrometry.

D The sample does not need a carrier gas.

Your answer ☐ **[1]**

10 Which equation could represent a fusion reaction in the Sun?

A $^{1}H + {}^{1}H \longrightarrow {}^{2}H$

B $^{2}H + {}^{1}H \longrightarrow {}^{3}H$

C $^{3}H + {}^{2}H \longrightarrow {}^{4}He + {}^{1}H$

D $^{3}He + {}^{3}He \longrightarrow {}^{4}He + 2\,{}^{1}H$

Your answer ☐ **[1]**

11 Which compound has the lowest boiling point?

A $CH_3CH_2CH_2CH_2Cl$

B $CH_3CH_2CH_2CH_2OH$

C $(CH_3)_3COH$

D $(CH_3)_2CHCH_2Cl$

Your answer ☐ **[1]**

12 Which reaction involves heterolytic fission of halogen molecules?

A The formation of chlorine radicals from chlorine molecules.

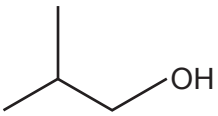
B The electrophilic substitution of chlorine with alkenes.

C The substitution reaction of halogens with alkanes.

D The reaction of hydrogen bromide with alkenes.

Your answer ☐ **[1]**

13 What happens when the compound shown is distilled with acidified potassium dichromate(VI)?



A No new product is formed.

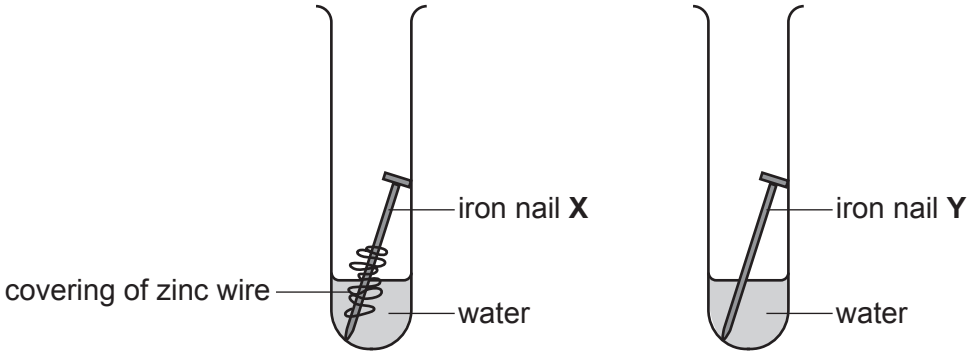
B An aldehyde is formed.

C A ketone is formed.

D A carboxylic acid is formed.

Your answer ☐ **[1]**

14 **X** is an iron nail partially covered in zinc. **Y** is a plain iron nail.



Which statement about rusting is correct?

A **X** will rust at the same rate as **Y** as it is not fully covered.

B **Y** will rust faster than **X**, which is protected by the zinc.

C **X** will rust faster than **Y** since zinc is more reactive than iron.

D **Y** will rust faster than **X** if copper replaces the zinc around **X**.

Your answer ☐ **[1]**

15 Which statement about an enzyme reaction is correct?

A Enzymes only work over a narrow range of pH values.

B Enzymes only work over a 10 °C range of temperature.

C The reaction is always zero order with respect to the enzyme.

D The reaction is always zero order with respect to the substrate.

Your answer ☐ **[1]**

16 Manganate(VII) and iron(II) ions react as shown.

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

What volume, in cm^3, of 0.10 mol dm^{-3} Fe^{2+} will react with 25 cm^3 of 0.050 mol dm^{-3} MnO_4^-?

A 2.5

B 12.5

C 62.5

D 125

Your answer ☐ **[1]**

17 What is the pH of a 0.005 mol dm^{-3} solution of NaOH?

A 1.3

B 2.3

C 11.7

D 12.7

Your answer ☐ **[1]**

18 Insulin is a protein consisting of two chains. Parts of both chains are helical.
The two chains are held together by covalent bonds.

Which statement about insulin is correct?

A The covalent bonds holding the chains together are –S–S– bonds.

B The overall folding of the helical parts and the other parts of the molecule is called its secondary structure.

C The helical parts are held in shape by peptide links.

D The helical parts are the primary structure.

Your answer ☐ **[1]**

19 A solution of lead nitrate is added to sodium sulfate and potassium iodide solutions.

What is observed?

	Observation with:	
	Sodium sulfate	**Potassium iodide**
A	Yellow precipitate	White precipitate
B	No precipitate	White precipitate
C	White precipitate	Yellow precipitate
D	White precipitate	No precipitate

Your answer ☐ **[1]**

20 Electromagnetic radiation with frequency 8.34×10^{14} Hz breaks a bond.

What is the bond enthalpy of the bond in $kJ\,mol^{-1}$?

A 1.44×10^{-7}

B 0.111

C 333

D 902

Your answer ☐ **[1]**

21 A student plots $\ln k$ (y-axis) against $1/T$ (in K^{-1}) for a reaction. The student gets a straight line graph that corresponds to the Arrhenius equation:

$\ln k = -E_a/RT + \ln A$

Which statement is correct?

A The intercept on the x-axis is $\ln A$.

B The intercept on the y-axis is $\ln A$.

C The slope is E_a.

D The slope is E_a/R.

Your answer ☐ **[1]**

22 Which esterification reaction is correct?

A $(CH_3CO)_2O + C_2H_5OH \longrightarrow CH_3COOC_2H_5 + CH_3COOH$

B $(CH_3CO)_2O + 2CH_3OH \longrightarrow 2CH_3COOCH_3$

C $CH_3COOH + C_6H_5OH \longrightarrow CH_3COOC_6H_5 + H_2O$

D $CH_3COCl + C_2H_5OH \longrightarrow C_2H_5COOCH_3 + HCl$

Your answer ☐ **[1]**

23 Which formula has the correct systematic name?

	Formula	Name
A	C_2H_5COCl	propyl chloride
B	$HOCH_2CH_2OH$	ethylene glycol
C	CH_3CH_2CHO	propan-1-al
D	$(CH_3CH_2CO)_2O$	propanoic anhydride

Your answer ☐ **[1]**

24 CO and N_2 both have M_r values of 28.

What is the reason that CO and N_2 can be distinguished by **high-resolution** mass spectrometry?

A CO has a dipole, unlike N_2.

B CO is more reactive than N_2.

C The values of their M^+ peaks would be different.

D CO and N_2 would give different fragments.

Your answer ☐ **[1]**

25 Mg^{2+} has a higher charge density than Ca^{2+}.

Which statement is correct?

A $MgCO_3$ is more thermally stable than $CaCO_3$.

B The Mg^{2+} ion has a less exothermic enthalpy change of hydration than that of Ca^{2+}.

C The ionic radius of Mg^{2+} is greater than that of Ca^{2+}.

D The lattice enthalpy of $MgCl_2$ is more exothermic than that of $CaCl_2$.

Your answer ☐ **[1]**

26 How many unsaturated structural isomers are there with the formula C_5H_{10}?

A 3

B 5

C 6

D 9

Your answer ☐ **[1]**

27 100 cm^3 0.75 mol dm^{-3} hydrochloric acid is added to 2.5 g calcium carbonate (M_r = 100).

$2HCl + CaCO_3 \rightarrow CaCl_2 + CO_2 + H_2$

What volume of CO_2, in cm^3, is produced at RTP?

A 600

B 900

C 1800

D 3600

Your answer ☐ **[1]**

28 A manufacturer is producing a medicine.

The manufacturer considers the following ways of improving the process.

1 Raising the temperature to get the product more quickly.

2 Using a catalyst to get the product more quickly.

3 Reducing the number of steps in the process.

Which of these will result in a 'greener' process?

A 1, 2 and 3

B Only 1 and 2

C Only 2 and 3

D Only 1

Your answer ☐ **[1]**

29 Which compound(s) can be made from benzene in one step?

1 C_6H_5Cl

2 $C_6H_5NO_2$

3 $C_6H_5NH_2$

A 1, 2 and 3

B Only 1 and 2

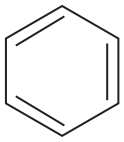
C Only 2 and 3

D Only 1

Your answer ☐ **[1]**

30 Benzene can be represented as structure **V** or as structure **W** as shown below.

structure V



structure W

Which of the following statement(s) is/are evidence for structure **V** rather than structure **W**?

1 The carbon – carbon bond lengths are all the same in benzene.

2 The bond angles are all the same in benzene.

3 The enthalpy change of hydrogenation of benzene is three times that of cyclohexene.

A 1, 2 and 3

B Only 1 and 2

C Only 2 and 3

D Only 1

Your answer ☐ **[1]**

SECTION B

Answer **all** the questions.

31 One of the components of diesel fuel for cars is cetane, $C_{16}H_{34}$.

(a) Write the equation for the complete combustion of cetane.

[1]

(b) Diesel vehicles are fitted with two-way catalytic convertors containing platinum, palladium and aluminium oxide. These catalyse the oxidation of hydrocarbons and carbon monoxide to carbon dioxide and water.

(i) State the **type** of catalysis in the catalytic convertor.

Explain your answer.

Type of catalysis .....

Explanation .....

..... **[2]**

(ii) How does the catalyst speed up the reaction?

.....

..... **[1]**

(c) There is a high air concentration in the air-fuel mix of diesel engines. This makes the formation of oxides of nitrogen more likely. The catalyst is not effective at removing oxides of nitrogen.

One oxide of nitrogen formed is nitrogen oxide, NO(g), which oxidises in air to form NO_2(g).

(i) State the appearance of NO and describe what is seen as it comes out of the exhaust pipe of a car.

.....

..... **[2]**

(ii) Write an equation for the formation of NO in the engine.

[1]

(d) Urea, $(NH_2)_2CO$, is used in the exhaust system to remove oxides of nitrogen.
The urea reacts in the exhaust system as shown in **equation 31.1**.

$$H_2O + (NH_2)_2CO \rightleftharpoons 2NH_3 + CO_2 \quad \Delta H = +113\,kJ\,mol^{-1}$$ **Equation 31.1**

(i) The forward reaction in **equation 31.1** is only feasible above a certain temperature.

Use the entropy values in the table to calculate this temperature.

Substance	Entropy, S / J mol^{-1} K^{-1}
H_2O	+ 69.9
$(NH_2)_2CO$	+ 173.9
NH_3	+ 192.3
CO_2	+ 213.6

temperature = ... K **[3]**

Equation 31.1 is repeated again below.

$H_2O + (NH_2)_2CO \rightleftharpoons 2NH_3 + CO_2 \quad \Delta H = +113\,kJ\,mol^{-1}$ **Equation 31.1**

(ii) The ammonia produced in **equation 31.1** reacts with oxygen and NO in the presence of a catalyst. Water and nitrogen are formed.

Construct the equation for this reaction.

[1]

(e) It has been stated that cars cause the most pollution on short journeys.

Evaluate this statement in terms of the rate and equilibrium position of the reaction shown in **equation 31.1**.

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..... **[4]**

(f) The urea used in the exhaust system is manufactured from ammonia and carbon dioxide. The production of ammonia is given by **equation 31.2**.

$N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$ **Equation 31.2**

In an experiment 5.0 moles of nitrogen and 12.0 moles of hydrogen are allowed to reach equilibrium in a 1.0 dm^3 container.

When analysing the equilibrium mixture, it was found that 6.0 moles of ammonia have been formed.

Calculate the concentrations of each gas at equilibrium and find the equilibrium constant for the equilibrium in **equation 31.2** under these conditions.

Include the units in your answer.

K_c = ... units ..... **[4]**

32 The Dead Sea has high concentrations of salts, especially chlorides and bromides.
Chlorine and bromine factories have developed next to the Dead Sea.

Many of the industries using chlorine and bromine as raw materials are located nearby. This avoids transporting these substances over long distances.

(a) Give **one** hazard of transporting chlorine or bromine.

.....

..... **[1]**

(b) The concentration of bromide ions in water from the Dead Sea is $5\,g\,dm^{-3}$.

Calculate the number of bromide **ions** in $1\,cm^3$ of Dead Sea water.

Give your answer to an **appropriate** number of significant figures.

number of bromide ions = ... **[3]**

(c) Chlorine is obtained by electrolysis. The chlorine is then used to obtain bromine from the bromide ions in the Dead Sea.

(i) Describe what is seen when chlorine is added to a solution of bromide ions.

..... **[1]**

(ii) Give an ionic equation for the reaction that takes place.

[1]

(iii) Explain, in terms of electrons, why the reaction takes place.

.....

..... **[1]**

(iv) The density of Dead Sea water is 1.24 kg dm^{-3}.
The concentration of chloride ions is 208 g dm^{-3}.

Calculate the volume of chlorine (in dm^3 at RTP) that is obtained by electrolysing 1.00 tonne of the water.

Give your answer in **standard form**.

volume of chlorine = ... dm^3 **[4]**

(d) Hydrogen chloride can be prepared by the action of concentrated sulfuric acid on sodium chloride.

$NaCl + H_2SO_4 \longrightarrow NaHSO_4 + HCl$

(i) Explain why hydrogen chloride is a gas at room temperature.

.....

..... **[1]**

(ii) Write an equation to show why hydrogen chloride dissolves in water to form an acidic solution.

[1]

(e) If the concentrated sulfuric acid is added to sodium bromide, some of the hydrogen bromide produced reacts with sulfuric acid to form sulfur dioxide and bromine.

(i) Complete the oxidation states of Br and S in the table.

	HBr	**H_2SO_4**	**Br_2**	**SO_2**
Oxidation state of Br	.....		.....	
Oxidation state of S		.....		.....

[2]

(ii) Construct an equation for the reaction of concentrated sulfuric acid with hydrogen bromide.

[1]

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33 Chloroethene is made in an industrial cracking reaction and is the monomer for making poly(chloroethene).

Chloroethene can be made from ethene in two steps:

Step 1 is the formation of $ClCH_2CH_2Cl$ from ethene.

Step 2 is thermal cracking of $ClCH_2CH_2Cl$ to eliminate HCl.

$$ClCH_2CH_2Cl \longrightarrow \underset{\text{chloroethene}}{CH_2{=}CHCl} + HCl$$

(a) Give the **repeat unit** of poly(chloroethene) and the **type of polymerisation** taking place when it is formed from chloroethene.

Repeat unit	Type of polymerisation
	.....

[2]

(b) The HCl produced in **step 2** can be used to make more $CH_2{=}CHCl$ by direct reaction with ethyne, HC≡CH.

Suggest the mechanism for the reaction of HCl with ethyne. Show dipoles and curly arrows.

[3]

(c) The $ClCH_2CH_2Cl$ produced in **step 1** can also be used to make other substances.

(i) Give the systematic name for $ClCH_2CH_2Cl$.

..... **[1]**

(ii) $ClCH_2CH_2Cl$ can be converted to $HOCH_2CH_2OH$ by refluxing with sodium hydroxide solution.

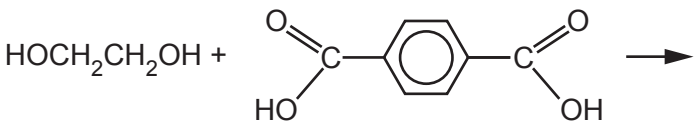
Name the mechanism for this reaction.

..... **[1]**

(iii) The $HOCH_2CH_2OH$ and a dicarboxylic acid are reacted together to make another polymer.

Complete the equation for the reaction below.

Show one repeat unit of the polymer.



[2]

(d)* Propene is also produced by a cracking reaction.

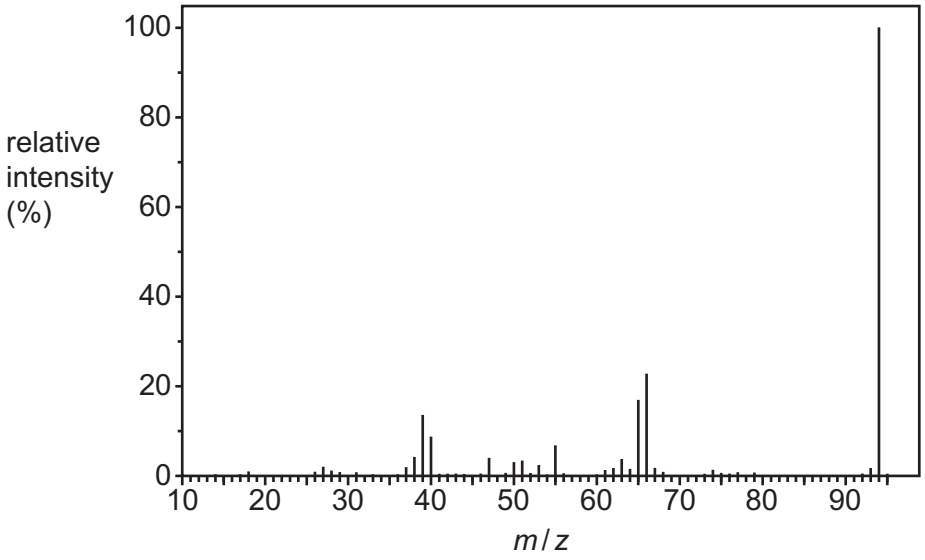
Propene can be reacted with benzene in the presence of oxygen to produce two useful products, **A** and **B**.

A student did some tests on the products and recorded their observations below. The student also obtained data about each product.

Student's tests on **Product A**:

Test	Observations
Add a drop of universal indicator.	orange colour produced
Add sodium carbonate solution.	no effervescence
Add neutral iron(III) chloride solution.	purple colour seen

The mass spectrum of **Product A**:



Student's tests on **Product B**:

Test	Observations
Add a drop of universal indicator.	stays green
Test with Tollens' reagent.	no change seen
React with $NaBH_4$.	**B** is reduced to an alcohol

Composition of **Product B**:

Element	C	H	O
Percentage by mass	62.1	10.3	27.6

You may do working on this page but it will not be marked.

Identify products **A** and **B** giving evidence from the student's observations and the data provided. **[6]**

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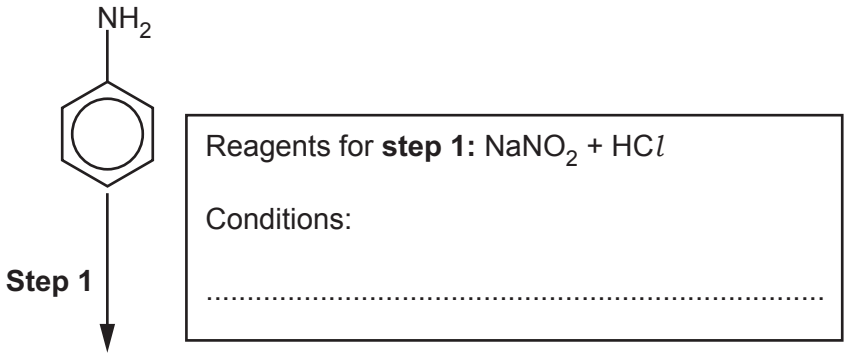
34 Some students want to synthesise dyes that will bind well to wool fibres.

They read that they can make coloured molecules using coupling reactions between phenols and diazonium ions.

(a) The students synthesise **dye C**, shown below, in two steps.

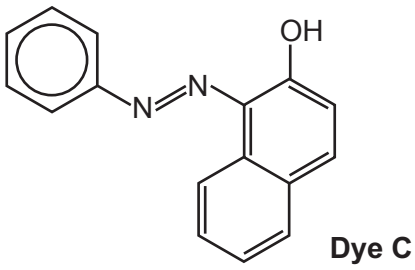
Complete the reaction sequence by filling in the boxes.



Product of **step 1:**

Step 2

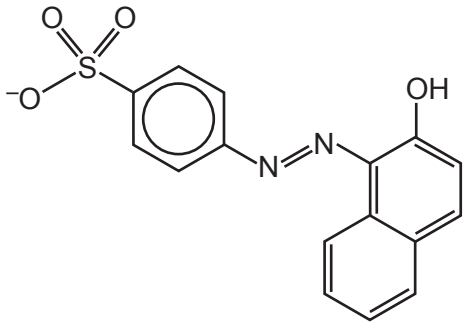
Reagent for **step 2:**



Dye C

[3]

(b) **Dye C** can be modified to form the more useful dye **D**, shown below.



Dye D

(i) Suggest a reagent and the conditions that would turn **dye C** into **dye D**.

.....

..... **[1]**

(ii) Comment on the solubility of the two dyes in water.

In your answer consider intermolecular bonds and their relative strengths.

Solubility of **dye C** .....

.....

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.....

Solubility of **dye D** .....

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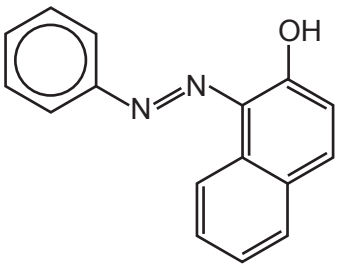
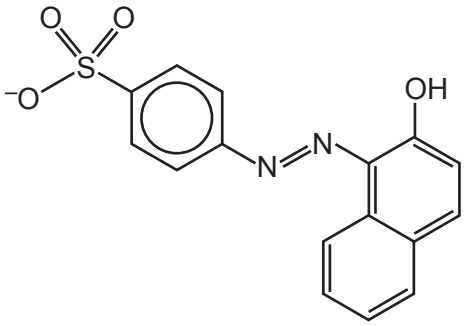
[4]

Dye C and **dye D** are repeated again below.



Dye C



Dye D

(c) **Dye C** has an orange colour.

(i) Explain why **dye C** absorbs visible light.

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..... **[3]**

(ii) How is the colour of the light absorbed related to the light seen?

.....

..... **[1]**

(d) Wool is based on protein structures.

Explain how **dye D** might bind to the wool fibres in weakly acidic conditions.

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..... **[2]**

(e)* The students have some wool samples that they have dyed. They want to find out how much of the dye washes out of the wool at different temperatures. They decide to use colorimetry.

Describe a suitable method for this experiment. Include the control variables in your answer.
[6]

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35 Some students want to find the concentration of chloride ions in seawater. They look up a method in a textbook.

They dilute the seawater and then titrate with standard silver nitrate, $AgNO_3$, solution.

(a) (i) Describe what is observed when silver nitrate is added to the seawater.

..... **[1]**

(ii) Give an ionic equation for the reaction, including state symbols.

[1]

(b) The students first dilute the seawater by pipetting 20.0 cm^3 of seawater into a 100 cm^3 volumetric flask and making up to the mark with deionised water.

25.0 cm^3 of the diluted seawater solution required 26.50 cm^3 0.100 mol dm^{-3} silver nitrate solution.

Calculate the concentration of chloride ions in the undiluted seawater.

concentration of chloride ions in seawater = ... mol dm^{-3} **[3]**

(c) 1.0 cm^3 0.25 $mol\,dm^{-3}$ potassium chromate(VI), K_2CrO_4, is added as an indicator.

At the end-point, all the silver chloride has been precipitated in the 52.5 cm^3 solution. A slight excess of silver ions causes a red-brown precipitate of silver chromate(VI) to form.

$2Ag^+(aq) + CrO_4^{2-}(aq) \rightarrow Ag_2CrO_4(s)$

(i) The solubility product of silver chloride is:

$K_{sp} = 2.0 \times 10^{-10}\ mol^2\,dm^{-6}$

Use this value to explain why $[Ag^+] = 1.41 \times 10^{-5}\ mol\,dm^{-3}$ at the end-point.

.....

..... **[2]**

(ii) The solubility product of silver chromate(VI) is:

$K_{sp} = [Ag^+]^2\,[CrO_4^{2-}] = 3.0 \times 10^{-12}\ mol^3\,dm^{-9}$

Perform a calculation to show whether a precipitate of silver chromate(VI) would form before all the Cl^- ions have reacted with the Ag^+ ions.

[3]

END OF QUESTION PAPER

ADDITIONAL ANSWER SPACE

If additional space is required, you should use the following lined page(s). The question number(s) must be clearly shown in the margin(s).