This is a Class 1 exam

Lebanon Evangelical School
for Boys and Girls
Loueizch - Baabda

# Stage Exam 04

## 12FEB2024

| Do NOT write in this box. Your MARK will be placed here. |
|---|
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| | |
|---|---|
| Subject : | A Level : Chemistry 2 |
| Class : | 12A |
| Teacher : | Mrs. Saydeh Nasrallah |
| Duration : | 1 hour |

| | | |
|---|---|---|
| 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 15 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.** An electrochemical cell consists of a standard hydrogen electrode and a $Cu^{2+}(aq)|Cu(s)$ electrode which uses copper(II) sulfate solution.
Which one of the following does **not** affect the e.m.f. of the cell?

☒ **A** The volume of the copper(II) sulfate solution.
☒ **B** The temperature.
☐ **C** The pressure of the hydrogen.
☐ **D** The concentration of the copper(II) sulfate solution.

**(Total for Question 1 = 1 mark)**

**2.** Which answer corresponds to the correct value of $E^{\ominus}_{cell}$ for the oxidation of hydrogen peroxide by manganate(VII) ions?

The half-reactions are

$$2H^+ + O_2 + 2e^- \rightleftharpoons H_2O_2 \qquad E^{\ominus} = +0.68\ V$$

$$MnO_4^- + 8H^+ + 5e^- \rightleftharpoons Mn^{2+} + 4H_2O \qquad E^{\ominus} = +1.51\ V$$

The overall equation is

$$2MnO_4^- + 6H^+ + 5H_2O_2 \rightarrow 2Mn^{2+} + 8H_2O + 5O_2$$

☐ **A** $E^{\ominus}_{cell} = +2.19\ V$
☐ **B** $E^{\ominus}_{cell} = -0.83\ V$
☐ **C** $E^{\ominus}_{cell} = -0.38\ V$
☐ **D** $E^{\ominus}_{cell} = +0.83\ V$

**(Total for Question 2 = 1 mark)**

**3.** Hydrogen peroxide, $H_2O_2$, can be analysed by titration. The hydrogen peroxide solution is treated with acidified potassium iodide, KI, solution, and the liberated iodine, $I_2$, is titrated with a standard solution of sodium thiosulfate, $Na_2S_2O_3$.

The products are iodide ions, $I^-$, and tetrathionate ions, $S_4O_6^{2-}$.
Which of the following applies to this reaction?

| | Action of $H_2O_2$ | Action of $S_2O_3^{2-}$ |
|---|---|---|
| **A** | Oxidising agent | Oxidising agent |
| **B** | Oxidising agent | Reducing agent |
| **C** | Reducing agent | Oxidising agent |
| **D** | Reducing agent | Reducing agent |

**(Total for Question 3 = 1 mark)**

**4.** Which of the following gives the oxidation states of manganese in the ions shown?

| | $MnO_4^{2-}$ | $MnO_3^-$ |
|---|---|---|
| **A** | +7 | +6 |
| **B** | +6 | +5 |
| **C** | +7 | +5 |
| **D** | +6 | +6 |

**(Total for Question 4 = 1 mark)**

**5.** For the nitration of phenol, which is the most suitable set of conditions and the reason for its use?

| | Conditions | Reactivity of phenol to electrophiles compared with benzene |
|---|---|---|
| **A** | Dilute nitric acid at room temperature | More reactive |
| **B** | Concentrated nitric acid and sulfuric acid at room temperature | More reactive |
| **C** | Concentrated nitric acid and sulfuric acid at 55°C | The same |
| **D** | Dilute nitric acid and dilute sulfuric acid at room temperature | Less reactive |

**(Total for Question 5 = 1 mark)**

**6.** Which sequence shows the bases in order of decreasing strength?

- **A** $C_6H_5NH_2 > CH_3NH_2 > NH_3$
- **B** $NH_3 > CH_3NH_2 > C_6H_5NH_2$
- **C** $CH_3NH_2 > NH_3 > C_6H_5NH_2$
- **D** $NH_3 > C_6H_5NH_2 > CH_3NH_2$

**(Total for Question 6 = 1 mark)**

**7.** On combustion, 0.50 mol of a primary alcohol produced 45 g of water and 88 g of carbon dioxide.
The alcohol could be

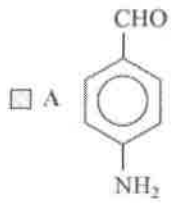
- **A** ethanol
- **B** propan-1-ol
- **C** butan-1-ol
- **D** pentan-1-ol

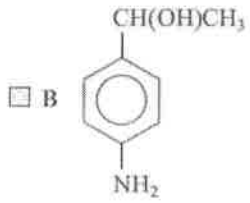
**(Total for Question 7 = 1 mark)**

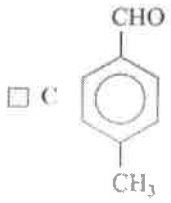
**8.** An organic compound, **X**, shows the following properties:

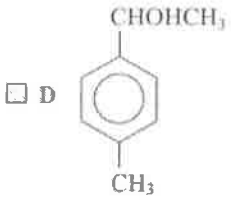
- Oxidation of compound **X** produces a substance that reacts with 2,4-dinitrophenylhydrazine to give a yellow precipitate but does not react with Fehling's or Benedict's solution.
- Compound **X** reacts with ice-cold nitrous acid to form a compound that gives a yellow precipitate with an alkaline solution of phenol.

What is the formula of compound **X**?

☐ A 

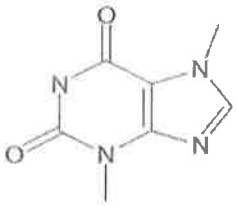

☐ B 


☐ C 


☐ D 


**(Total for Question 8 = 1 mark)**

**9.** The diagram shows the skeletal structure of theobromine, which has a bitter taste and is found in chocolate and tea leaves.



Which of the functional groups listed is **not** present in the structure?

- ☐ **A** alkyl
- ☐ **B** amide
- ☐ **C** amine
- ☐ **D** ketone

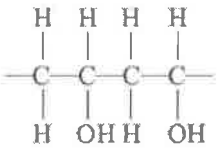
**(Total for Question 9 = 1 mark)**

**10.** Evidence that the carbon-carbon bonds in benzene are all the same length is provided by

- ☐ **A** X-ray diffraction.
- ☒ **B** infrared spectroscopy.
- ☒ **C** a comparison of the enthalpy changes for the addition of hydrogen to benzene and the theoretical compound cyclohexa-1,3,5-triene.
- ☐ **D** a comparison of the rates of reaction of benzene and alkenes with bromine.

**(Total for Question 10 = 1 mark)**

**11.** Poly(ethenol) is a water-soluble polymer. A section of the chain has the structure shown below.

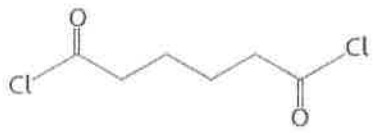


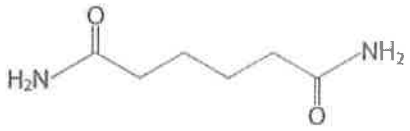
The polymer is used for making hospital laundry bags so that laundry can be loaded directly into washing machines without it having to be handled.
Poly(ethenol) is water soluble because the polymer

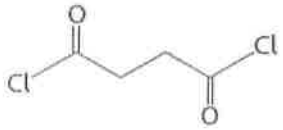
- ☐ **A** is broken down by the water into monomers.
- ☐ **B** is broken down by the washing detergent.
- ☐ **C** breaks into monomers at the temperature of the wash.
- ☐ **D** forms many strong hydrogen bonds with the water.

**(Total for Question 11 = 1 mark)**

**12.** The formula of the repeat unit of a polymer is $-[OC(CH_2)_4CONH(CH_2)_6NH]-$.
The polymer is formed by the reaction of

☐ **A**  and 

☐ **B**  and 

☐ **C**  and 

☐ **D**  and 

**(Total for Question 12 = 1 mark)**

**TOTAL FOR SECTION A = 12 MARKS**

## SECTION B

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

**13.** Amino acids can be separated using chromatography.

(a) State how chromatography separates the components of a mixture.

(1)

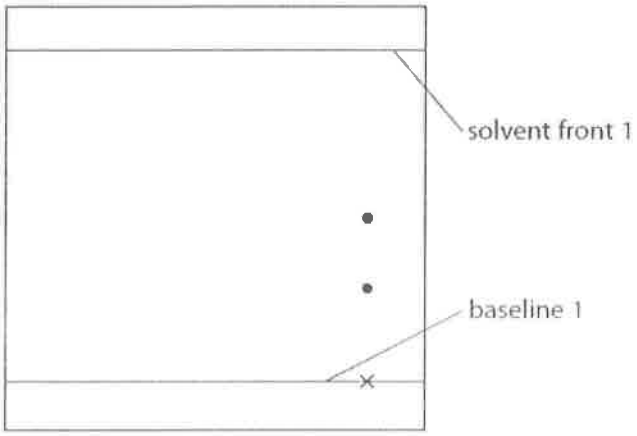
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(b) A sample of a tripeptide was hydrolysed and then placed on an 'X' at the bottom right-hand corner of a piece of chromatography paper.
A simplified diagram of a developed chromatogram is shown.




(i) Give a possible reason for the presence of only two spots for the tripeptide other than two amino acids have almost identical $R_f$ values.

(1)

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(ii) Name a reagent that locates colourless amino acids by producing a coloured compound.

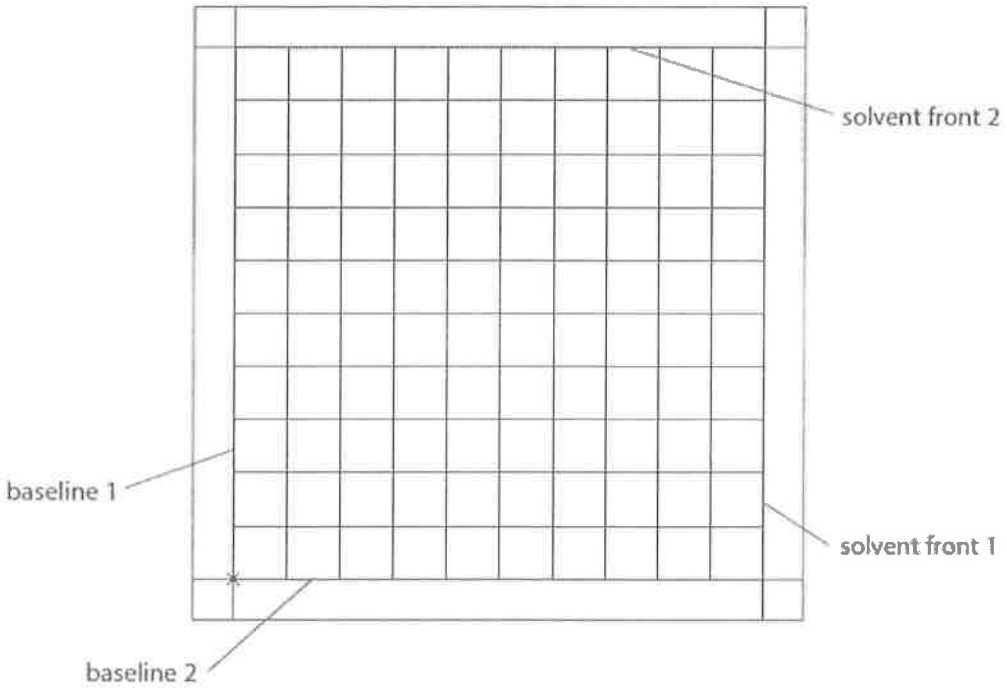
(1)

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(iii) Some amino acid mixtures cannot be effectively separated in one chromatography 'run'.
The chromatography paper from the first run is dried but not developed.
The chromatography paper is then rotated clockwise by 90° and placed in a different solvent.
Complete the simplified diagram of the developed chromatography paper after a second 'run' for a tripeptide of alanine, glycine and valine by adding **labelled** spots for each amino acid.

| Amino acid | $R_f$ in solvent 1 | $R_f$ in solvent 2 |
|---|---|---|
| Alanine | 0.38 | 0.43 |
| Glycine | 0.33 | 0.26 |
| Valine | 0.39 | 0.58 |

(3)




(c) State the technique that is used in conjunction with gas chromatography (GC) when carrying out forensic testing.

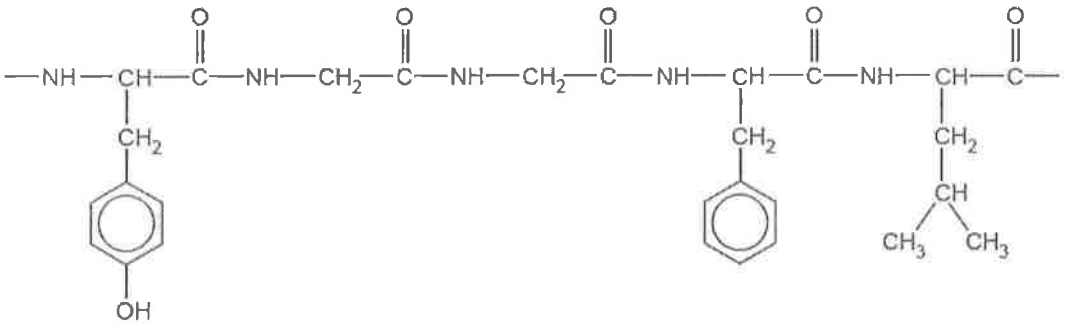
(1)

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(d) Some students hydrolyse a protein in the laboratory by refluxing it with moderately concentrated hydrochloric acid.

(i) Circle all the chiral centres in the section of protein shown below.

(1)

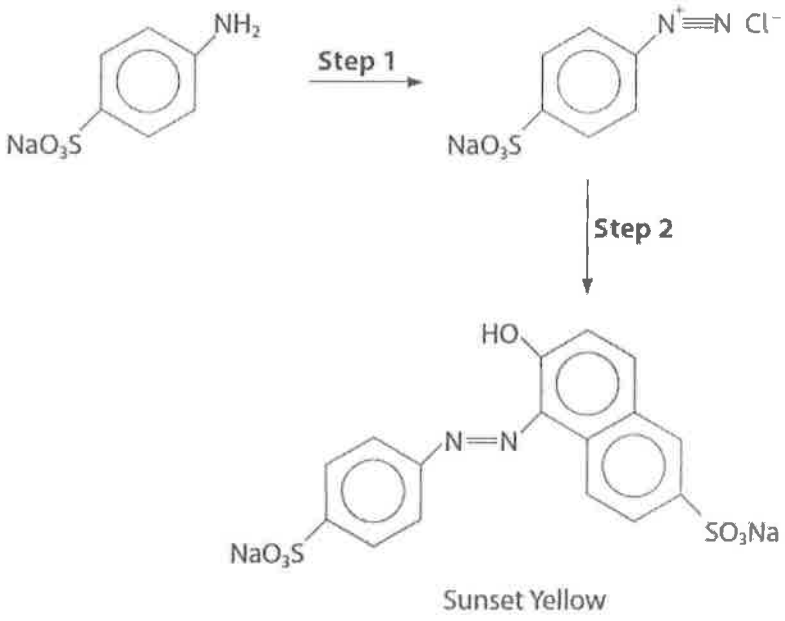


(ii) Give the organic products of the complete hydrolysis of this protein section with hydrochloric acid.

(4)

**(Total for Question 13 = 12 marks)**

**14.** The food colouring E110 is also known as Sunset Yellow. It can be synthesised as shown below.




Sunset Yellow

(a) Give the reagents and condition for **Step 1**.

(2)

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(b) Draw the structure of the reagent needed for **Step 2**.

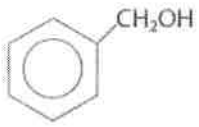
(1)

*(c) Describe the essential steps of the method that you would use to prepare a pure, dry sample of the solid Sunset Yellow from an impure sample of the food colouring.
You may assume that ethanol is a suitable solvent for this method.

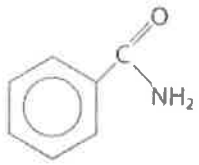
(4)

(d) Devise a synthetic route to produce benzamide from phenylmethanol using three steps. Include the reagents for each step and draw the structures of **all** the intermediates.

(5)



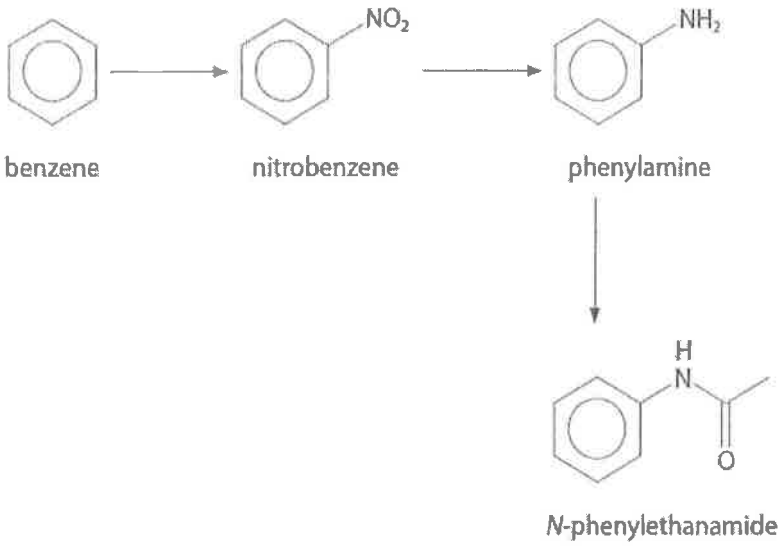

phenylmethanol




benzamide

**(Total for Question 14 = 12 marks)**

**15.** N-phenylethanamide, historically used as a painkiller, can be synthesised from benzene as shown.




(a) Concentrated nitric acid reacts with a second reagent to produce an electrophile. This electrophile reacts with benzene to form nitrobenzene.

(i) Identify, by name or formula, the second reagent and the electrophile.

(2)

.....

.....

(ii) Draw the mechanism for the reaction between the electrophile and benzene to form nitrobenzene. Include the equation for the formation of the electrophile.

(4)

(b)(i) Identify, by name or formula, the reagent(s) required to convert nitrobenzene into phenylamine.

(1)

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(ii) State the type of reaction occurring during this step.

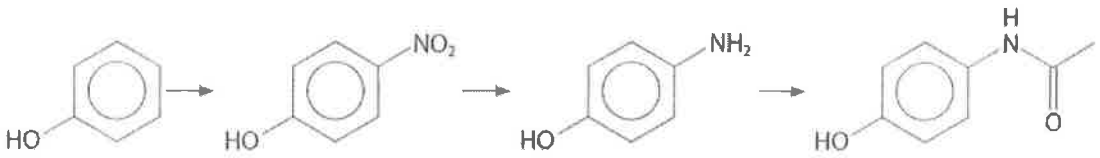
(1)

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(c) The overall yield for the synthesis of N-phenylethanamide from benzene was found to be 35.2%. Calculate the minimum volume of benzene, in $cm^3$, required to make 10.0 g of N-phenylethanamide.
[Density of benzene = 0.879 $g.cm^{-3}$]

(4)

(d) Another painkiller, paracetamol, can be synthesised from phenol in a similar sequence.
Phenol is nitrated by dilute nitric acid.




phenol 4-nitrophenol 4-aminophenol paracetamol

Explain why the nitration of phenol requires much milder conditions than the formation of nitrobenzene.

(2)

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**(Total for Question 15 = 14 marks)**

**TOTAL FOR SECTION B = 38 MARKS**
**TOTAL FOR PAPER = 50 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<br>atomic symbol<br>name<br>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 |

## SECTION A

**Answer ALL the questions in this section.**
**You should aim to spend no more than 15 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.** An electrochemical cell consists of a standard hydrogen electrode and a $Cu^{2+}(aq)|Cu(s)$ electrode which uses copper(II) sulfate solution.
Which one of the following does **not** affect the e.m.f. of the cell?

(1) ✓

☒ **A** The volume of the copper(II) sulfate solution.
☐ **B** The temperature.
☐ **C** The pressure of the hydrogen.
☐ **D** The concentration of the copper(II) sulfate solution.

**(Total for Question 1 = 1 mark)**

**2.** Which answer corresponds to the correct value of $E^{\ominus}_{cell}$ for the oxidation of hydrogen peroxide by manganate(VII) ions?

The half-reactions are

$$2H^+ + O_2 + 2e^- \rightleftharpoons H_2O_2 \qquad E^{\ominus} = +0.68\ V$$

$$MnO_4^- + 8H^+ + 5e^- \rightleftharpoons Mn^{2+} + 4H_2O \qquad E^{\ominus} = +1.51\ V$$

The overall equation is

$$2MnO_4^- + 6H^+ + 5H_2O_2 \rightarrow 2Mn^{2+} + 8H_2O + 5O_2$$

☐ **A** $E^{\ominus}_{cell} = +2.19\ V$
☐ **B** $E^{\ominus}_{cell} = -0.83\ V$
☐ **C** $E^{\ominus}_{cell} = -0.38\ V$
☒ **D** $E^{\ominus}_{cell} = +0.83\ V$ (1) ✓

**(Total for Question 2 = 1 mark)**

**3.** Hydrogen peroxide, $H_2O_2$, can be analysed by titration. The hydrogen peroxide solution is treated with acidified potassium iodide, KI, solution, and the liberated iodine, $I_2$, is titrated with a standard solution of sodium thiosulfate, $Na_2S_2O_3$.

The products are iodide ions, $I^-$, and tetrathionate ions, $S_4O_6^{2-}$.
Which of the following applies to this reaction?

| | Action of $H_2O_2$ | Action of $S_2O_3^{2-}$ |
|---|---|---|
| ☐ **A** | Oxidising agent | Oxidising agent |
| ☒ **B** | Oxidising agent | Reducing agent |
| ☐ **C** | Reducing agent | Oxidising agent |
| ☐ **D** | Reducing agent | Reducing agent |

**(Total for Question 3 = 1 mark)**

**4.** Which of the following gives the oxidation states of manganese in the ions shown?

| | $MnO_4^{2-}$ | $MnO_3^-$ |
|---|---|---|
| ☐ **A** | +7 | +6 |
| ☒ **B** | +6 | +5 |
| ☐ **C** | +7 | +5 |
| ☐ **D** | +6 | +6 |

**(Total for Question 4 = 1 mark)**

**5.** For the nitration of phenol, which is the most suitable set of conditions and the reason for its use?

| | Conditions | Reactivity of phenol to electrophiles compared with benzene |
|---|---|---|
| ☒ **A** | Dilute nitric acid at room temperature | More reactive |
| ☐ **B** | Concentrated nitric acid and sulfuric acid at room temperature | More reactive |
| ☐ **C** | Concentrated nitric acid and sulfuric acid at 55°C | The same |
| ☐ **D** | Dilute nitric acid and dilute sulfuric acid at room temperature | Less reactive |

**(Total for Question 5 = 1 mark)**

**6.** Which sequence shows the bases in order of decreasing strength?

☐ **A** $C_6H_5NH_2 > CH_3NH_2 > NH_3$
☐ **B** $NH_3 > CH_3NH_2 > C_6H_5NH_2$
☒ **C** $CH_3NH_2 > NH_3 > C_6H_5NH_2$
☐ **D** $NH_3 > C_6H_5NH_2 > CH_3NH_2$

**(Total for Question 6 = 1 mark)**

**7.** On combustion, 0.50 mol of a primary alcohol produced 45 g of water and 88 g of carbon dioxide.
The alcohol could be

☐ **A** ethanol
☐ **B** propan-1-ol
☒ **C** butan-1-ol
☐ **D** pentan-1-ol

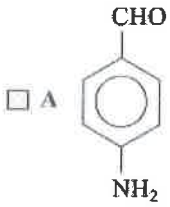
**(Total for Question 7 = 1 mark)**

**8.** An organic compound, **X**, shows the following properties:

- Oxidation of compound **X** produces a substance that reacts with 2,4-dinitrophenylhydrazine to give a yellow precipitate but does not react with Fehling's or Benedict's solution.
- Compound **X** reacts with ice-cold nitrous acid to form a compound that gives a yellow precipitate with an alkaline solution of phenol.

What is the formula of compound **X**?

☐ **A**



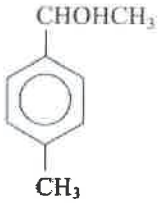

☒ **B**




☐ **C**

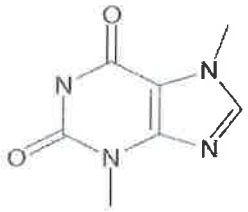



☐ **D**




**(Total for Question 8 = 1 mark)**

**9.** The diagram shows the skeletal structure of theobromine, which has a bitter taste and is found in chocolate and tea leaves.



Which of the functional groups listed is **not** present in the structure?

- ☐ **A** alkyl
- ☐ **B** amide
- ☐ **C** amine
- ☒ **D** ketone

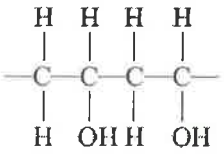
**(Total for Question 9 = 1 mark)**

**10.** Evidence that the carbon-carbon bonds in benzene are all the same length is provided by

- ☒ **A** X-ray diffraction.
- ☐ **B** infrared spectroscopy.
- ☐ **C** a comparison of the enthalpy changes for the addition of hydrogen to benzene and the theoretical compound cyclohexa-1,3,5-triene.
- ☐ **D** a comparison of the rates of reaction of benzene and alkenes with bromine.

**(Total for Question 10 = 1 mark)**

**11.** Poly(ethenol) is a water-soluble polymer. A section of the chain has the structure shown below.



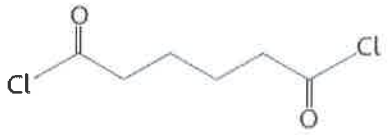
The polymer is used for making hospital laundry bags so that laundry can be loaded directly into washing machines without it having to be handled.
Poly(ethenol) is water soluble because the polymer

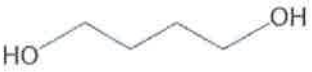
- ☐ **A** is broken down by the water into monomers.
- ☐ **B** is broken down by the washing detergent.
- ☐ **C** breaks into monomers at the temperature of the wash.
- ☒ **D** forms many strong hydrogen bonds with the water.

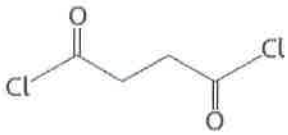
**(Total for Question 11 = 1 mark)**

**12.** The formula of the repeat unit of a polymer is $-[OC(CH_2)_4CONH(CH_2)_6NH]-$.
The polymer is formed by the reaction of

(1) ✓

☒ **A**  and 

☐ **B**  and 

☐ **C**  and 

☐ **D**  and 

**(Total for Question 12 = 1 mark)**

**TOTAL FOR SECTION A = 12 MARKS**

## SECTION B

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

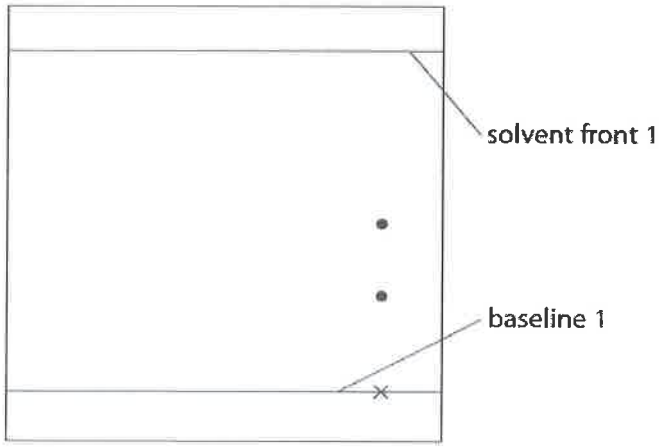
**13.** Amino acids can be separated using chromatography.

(a) State how chromatography separates the components of a mixture.

(1)

It's based on the affinity of the compound towards the eluant. (1)

(b) A sample of a tripeptide was hydrolysed and then placed on an 'X' at the bottom right-hand corner of a piece of chromatography paper.
A simplified diagram of a developed chromatogram is shown.




(i) Give a possible reason for the presence of only two spots for the tripeptide other than two amino acids have almost identical $R_f$ values.

(1)

There are only 2 different amino acids. (1)

(ii) Name a reagent that locates colourless amino acids by producing a coloured compound.

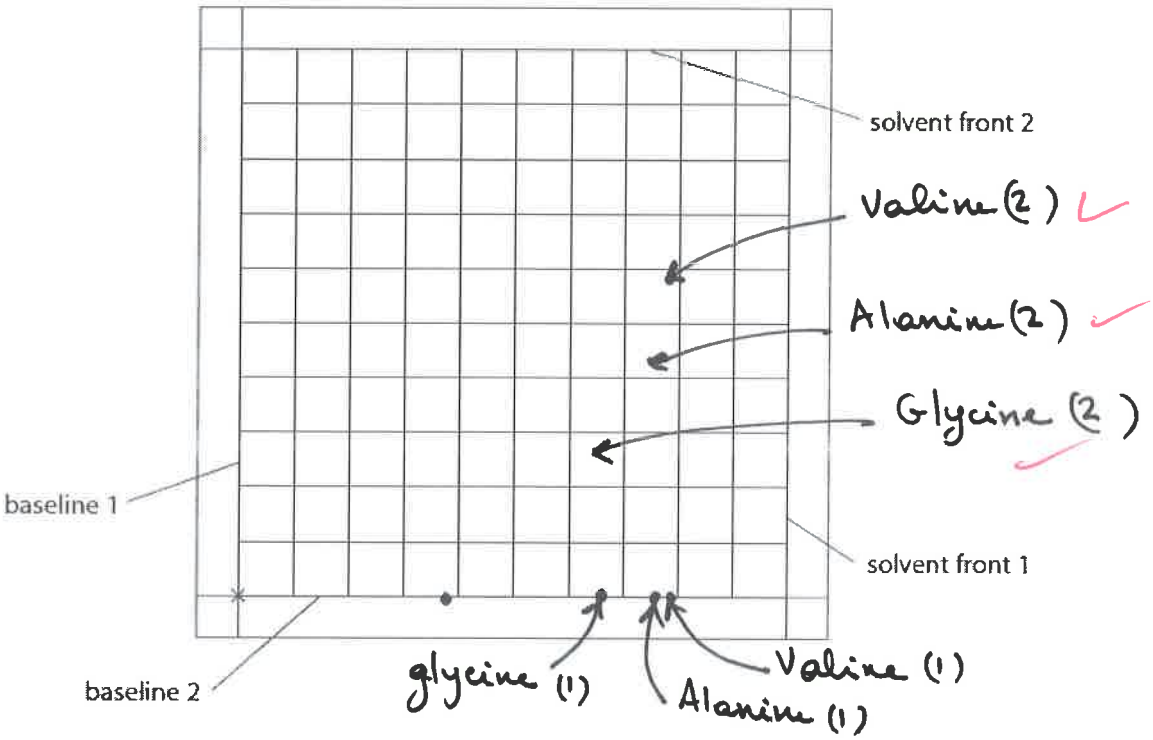
(1)

Ninhydrin (1)

(iii) Some amino acid mixtures cannot be effectively separated in one chromatography 'run'.
The chromatography paper from the first run is dried but not developed.
The chromatography paper is then rotated clockwise by 90° and placed in a different solvent.
Complete the simplified diagram of the developed chromatography paper after a second 'run' for a tripeptide of alanine, glycine and valine by adding **labelled** spots for each amino acid.

| Amino acid | $R_f$ in solvent 1 | $R_f$ in solvent 2 |
|---|---|---|
| Alanine | 0.38 | 0.43 |
| Glycine | 0.33 | 0.26 |
| Valine | 0.39 | 0.58 |

(3)




(c) State the technique that is used in conjunction with gas chromatography (GC) when carrying out forensic testing.

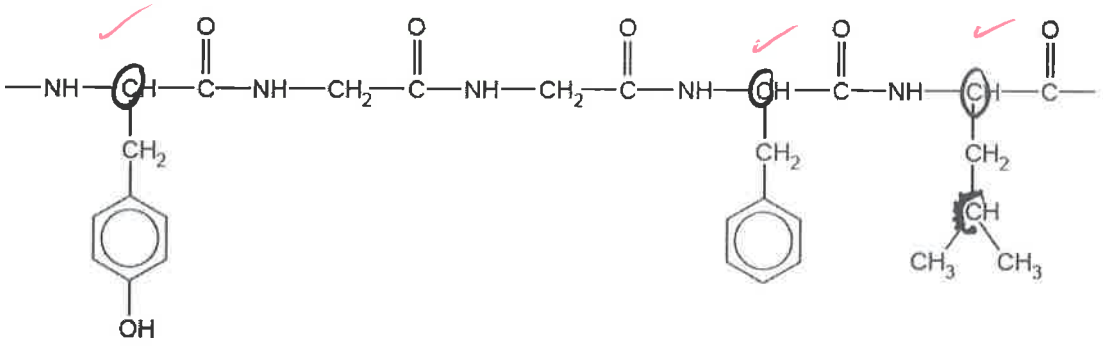
Mass spectrometry (1)

(1)

(d) Some students hydrolyse a protein in the laboratory by refluxing it with moderately concentrated hydrochloric acid.

(i) Circle all the chiral centres in the section of protein shown below.

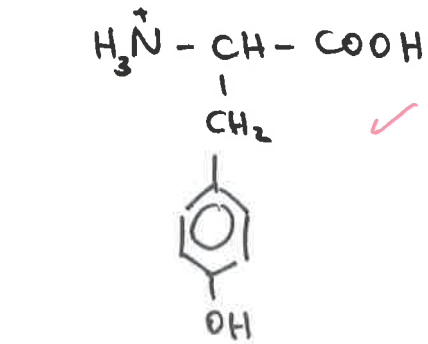
(1)

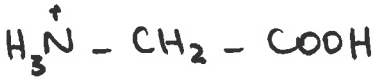


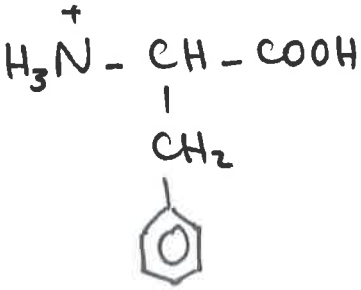
(1)

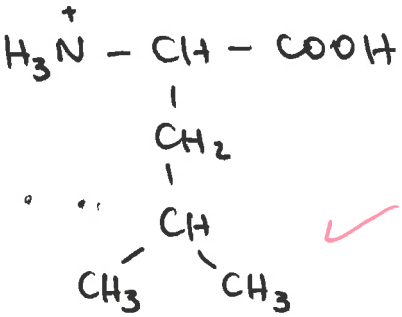
(ii) Give the organic products of the complete hydrolysis of this protein section with hydrochloric acid.

(4)





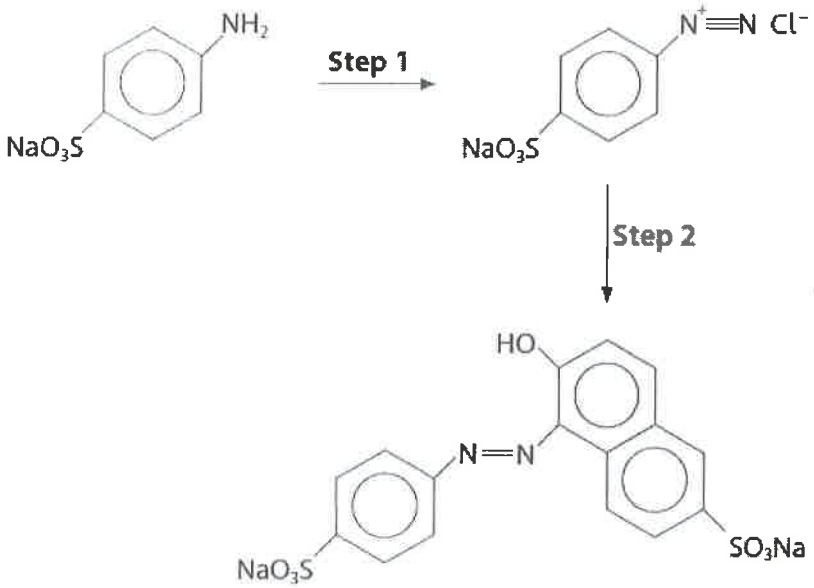




(4)

**(Total for Question 13 = 12 marks)**

**14.** The food colouring E110 is also known as Sunset Yellow. It can be synthesised as shown below.




Sunset Yellow

(a) Give the reagents and condition for **Step 1**.

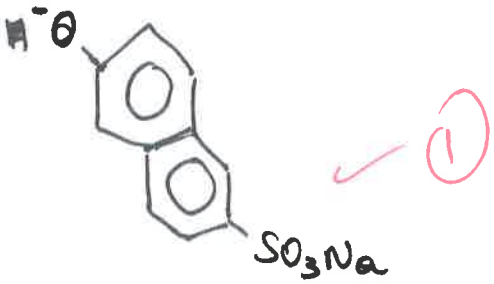
(2)

NaNO2 (s), HCl concentrated (1)

0 - 5 °C (1)

(b) Draw the structure of the reagent needed for **Step 2**.

(1)




(1)

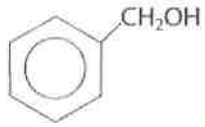
*(c) Describe the essential steps of the method that you would use to prepare a pure, dry sample of the solid Sunset Yellow from an impure sample of the food colouring.
You may assume that ethanol is a suitable solvent for this method.

(4)

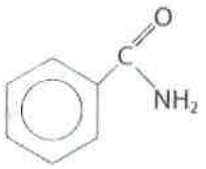
- Dissolve the solid sunset yellow in a minimum amount of hot ethanol such to prepare a saturated solution (1)
- Filter off the impurities while it's warm using preheated conical funnel and filter paper. (1)
- Place the collected filtrate in large basin and allow to cool and evaporate. (1)
- Collect the crystals formed using reduced pressure filtration
- Rinse the crystals using minimum amount of cold ethanol (1)
- Dab with dry filter paper, & place the crystals in dessicator.

(d) Devise a synthetic route to produce benzamide from phenylmethanol using three steps. Include the reagents for each step and draw the structures of **all** the intermediates.

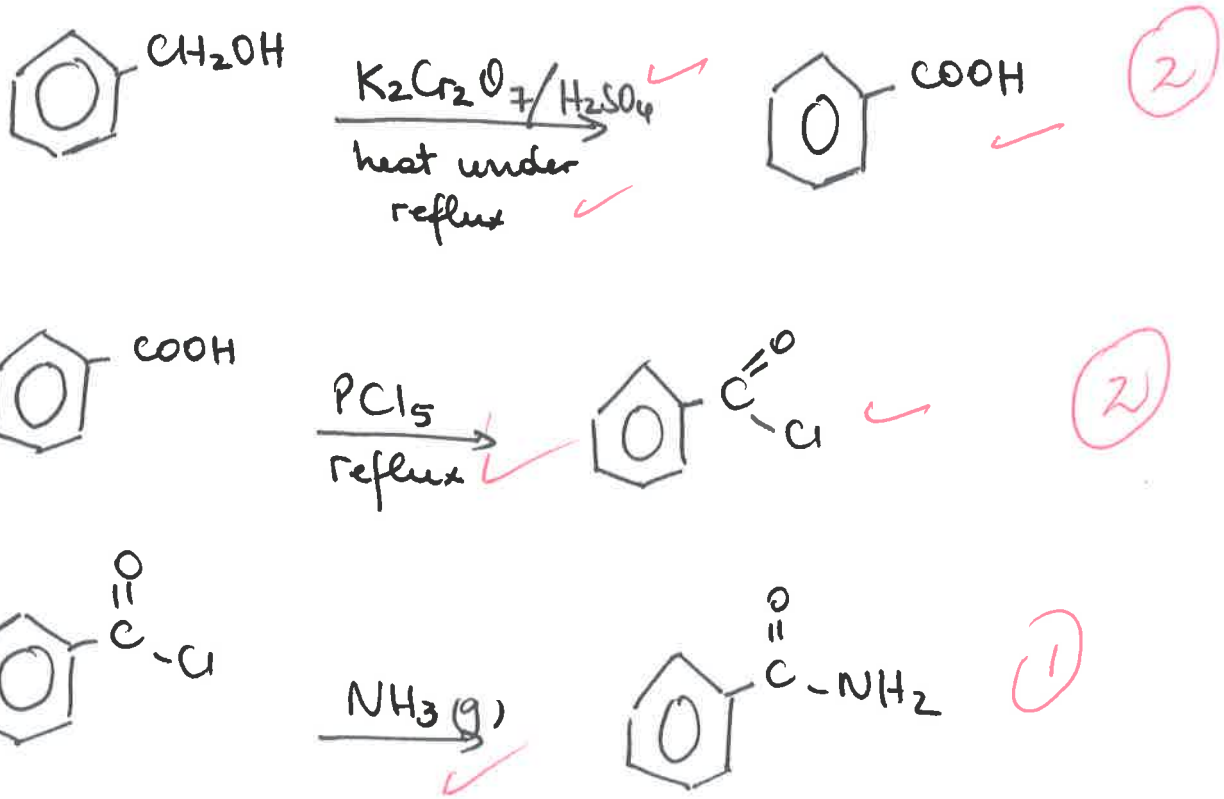
(5)




phenylmethanol

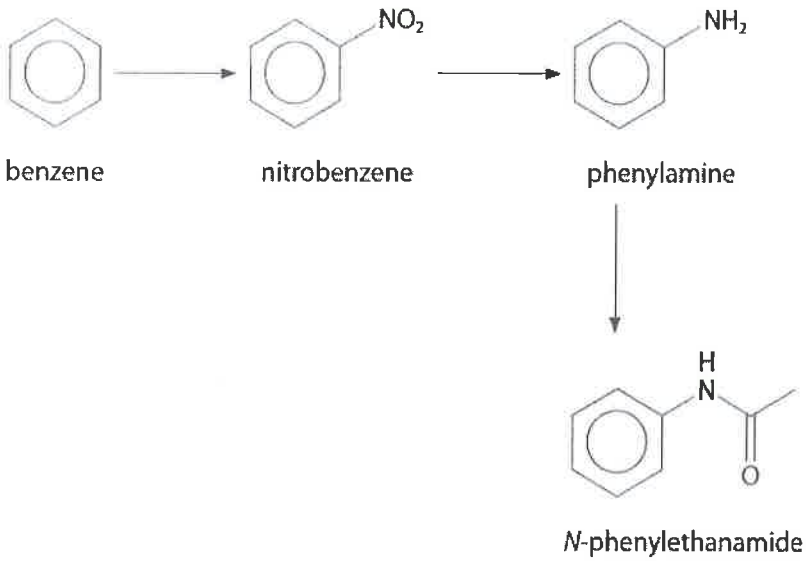



benzamide




**(Total for Question 14 = 12 marks)**

**15.** N-phenylethanamide, historically used as a painkiller, can be synthesised from benzene as shown.




(a) Concentrated nitric acid reacts with a second reagent to produce an electrophile. This electrophile reacts with benzene to form nitrobenzene.

(i) Identify, by name or formula, the second reagent and the electrophile.

(2)

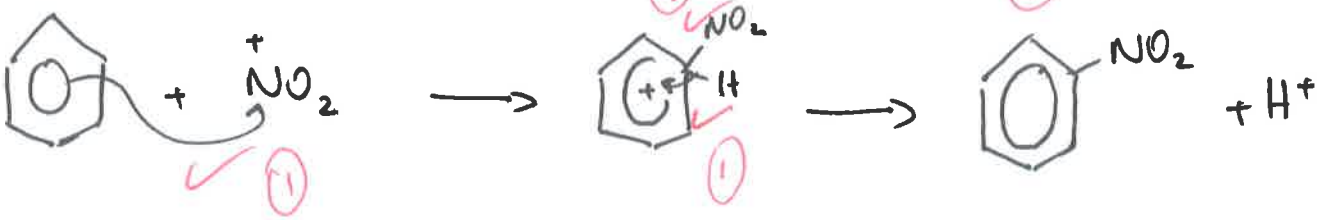
concentrated $H_2SO_4$ ✓(1)

$\overset{+}{N}O_2$ ✓(1)

(ii) Draw the mechanism for the reaction between the electrophile and benzene to form nitrobenzene. Include the equation for the formation of the electrophile.

(4)

$H_2SO_4 + HNO_3 \longrightarrow HSO_4^- + \overset{+}{N}O_2 + H_2O$ ✓(1)




✓(1) ✓(1) ✓(1)

$H^+ + HSO_4^- \longrightarrow H_2SO_4$

(b)(i) Identify, by name or formula, the reagent(s) required to convert nitrobenzene into phenylamine.

1) Sn/HCl 2) NaOH (1) (1)

(ii) State the type of reaction occurring during this step.

Reduction (1) (1)

(c) The overall yield for the synthesis of N-phenylethanamide from benzene was found to be 35.2%. Calculate the minimum volume of benzene, in $cm^3$, required to make 10.0 g of N-phenylethanamide.
[Density of benzene = 0.879 $g.cm^{-3}$]

(4)

$M_{(N\text{-phenylethanamide})} = 8 \times 12 + 14 + 16 + 9$

$= 135\ g.mol^{-1}$ (1)

Theoretical $m_{(N\text{-phenylethanamide}} = \frac{10.0}{35.2} \times 100 = 28.41\ g.$ (1)

$C_6H_6 : C_8H_9NO$

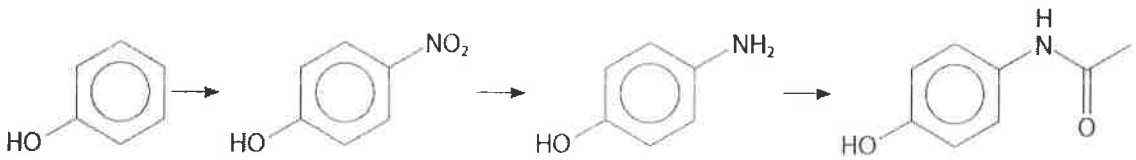
$1 : 1$

$\Rightarrow \frac{m_{C_6H_6}}{M_{C_6H_6}} = \frac{m_{C_8H_9NO}}{M_{C_8H_9NO}}$

$\Rightarrow m_{C_6H_6} = \frac{28.41 \times 78}{135} = 16.4\ g$ (1)

$\Rightarrow V_{C_6H_6} = \frac{m_{C_6H_6}}{d_{C_6H_6}} = \frac{16.4}{0.879} = 18.7\ cm^3$ (1)

(d) Another painkiller, paracetamol, can be synthesised from phenol in a similar sequence. Phenol is nitrated by dilute nitric acid.




phenol 4-nitrophenol 4-aminophenol paracetamol

Explain why the nitration of phenol requires much milder conditions than the formation of nitrobenzene.

(2)

The lone pair on oxygen in the hydroxyl group in phenol resonates along the $\pi$ system in benzene (1), thus enriching its $e^-$ density and making it more susceptible to electrophilic attacks. (1)

**(Total for Question 15 = 14 marks)**

**TOTAL FOR SECTION B = 38 MARKS**
**TOTAL FOR PAPER = 50 MARKS**

# The Periodic Table of Elements

| 1 | 2 | | | | | | | | | | | 3 | 4 | 5 | 6 | 7 | 0 (8) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | 1.0 H hydrogen 1 | | | | | | | | | | (18) 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<br>atomic symbol<br>name<br>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 |