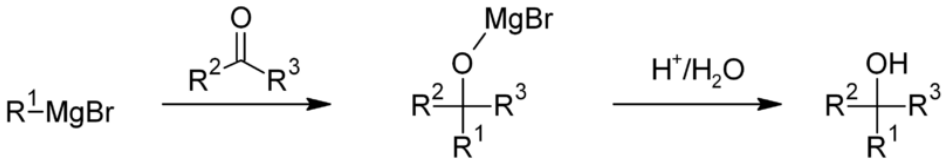
For Examiner's use

1 The Grignard reagent, R^1-MgBr, can be made by reaction between alkyl bromide and magnesium. In a Grignard reaction, the Grignard reagent may be added to a carbonyl compound for the formation of an alcohol. This reaction is useful for the formation of carbon–carbon bonds.

$$R^1Br + Mg \rightarrow R^1\text{-}MgBr$$



(a) The above reaction between the Grignard reagent and ketone can give a yield of about 80 %. You are required to prepare 4 g of 2-methylpropan-2-ol.

(i) Identify the alkyl bromide and ketone required to synthesise 2-methylpropan-2-ol.

……

[1]

(ii) Assuming that the alkyl bromide can be completely converted into the Grignard reagent, determine the mass of each reactant in **(a)(i)** needed to prepare the desired amount of the pure organic product.

[2]

For Examiner's use

(iii) Similar to the lithium aluminium hydride, the Grignard reagent is rapidly **destroyed by water and air**.

Give a suitable solvent and the condition required for the solvent in the synthesis of the Grignard reagent.

……

[1]

(b) The Grignard reagent was first prepared by adding an appropriate mass of magnesium to an appropriate mass of alkyl bromide dissolved in an appropriate volume of solvent. The mixture was then heated under reflux for about 30 minutes.

After cooling the reaction mixture which now contains the prepared Grignard reagent, a fixed amount of ketone was then slowly added dropwise to it with intermittent swirling and warming.

(i) You are provided with the following apparatus: two-necked round bottom flask, condenser, heating mantle and dropping funnel.

Draw a suitable set-up using the glassware provided for conducting the above experiment.

[2]

For Examiner's use

(ii) Write a step-by-step procedure on how you would prepare 4 g of the pure 2-methylpropan-2-ol using provided magnesium as well as the suggested alkyl bromide and ketone from your answers in **(a)(i)** bearing in mind that the yield in such a procedure is about 80 %.

Your plan should:

- show how the quantities of reactants calculated in **a(ii)** are used;
- show that the mass of magnesium used is in excess for complete conversion of the alkyl bromide to the Grignard reagent;
- use an appropriate volume of the solvent from your answer in **a(iii)**;
- ensure that the reactions are conducted under the appropriate condition.

……

……

……

……

……

……

……

……

……

……

……

……

……

……

……

……

……

……

……

……

……

……

5

For Examiner's use

……

……

……

……

……

……

……

……

……

……

……

……

……

……

……

……

……

……

……

……

……

……

……

[5]

For Examiner's use

(c) Excess unreacted magnesium in the reaction mixture could be destroyed by addition of sulfuric acid. Give a safety precaution, with reason, which you would take to perform the above step.

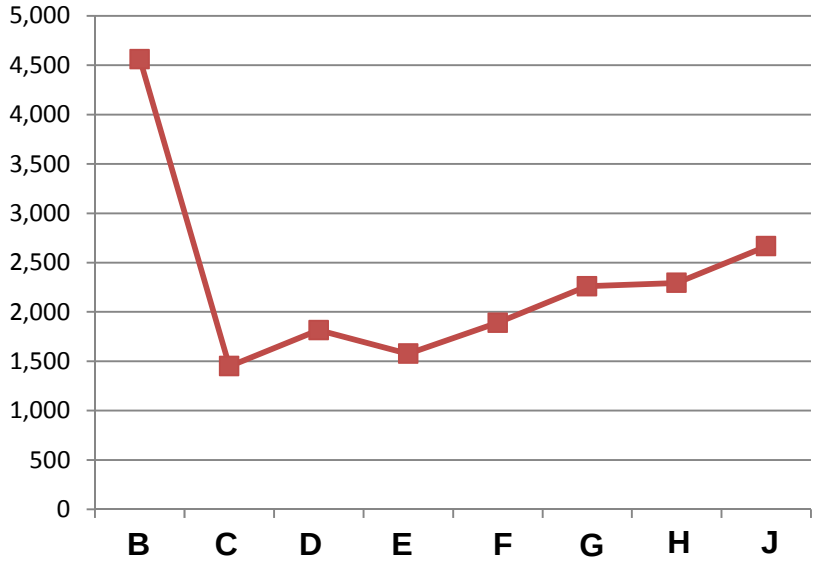
.....

.....

[1]

[Total: 12 marks]

2 The graph for the second ionisation energies of Period 3 elements is given below:



(a) **(i)** State the electronic configuration of element **D** and deduce the group which element **D** belongs to.

.....

.....

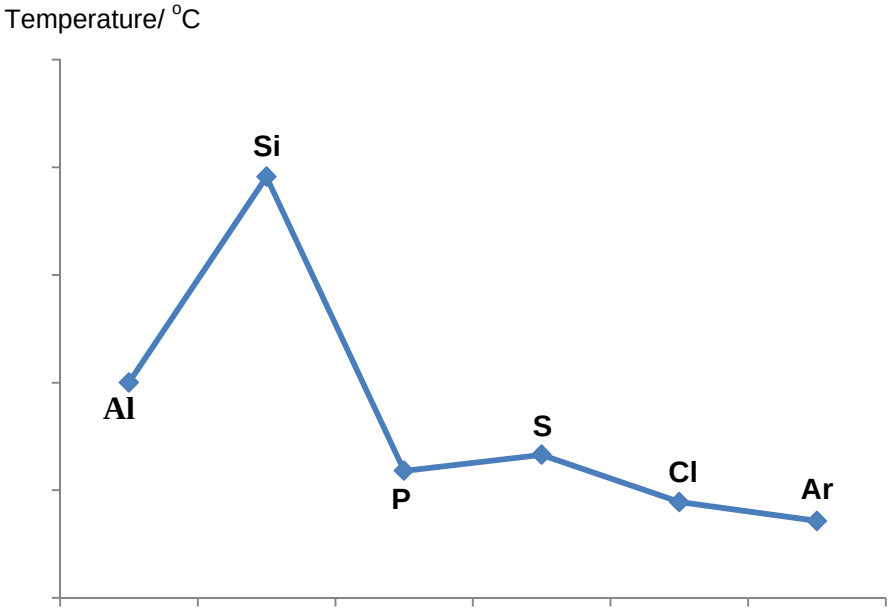
[2]

7

For Examiner's use

(ii) The figure below shows the melting points of six consecutive elements in the periodic table.

Explain in terms of structure and bonding the variation in melting points of the elements.



……

……

……

……

……

……

……

……

……

……

……

……

……

……

……

[4]

For Examiner's use

(b) Draw the dot and cross diagram for the compound $SiCl_4$.

[1]

(c) Silicon tetrachloride is a liquid at room temperature, phosphorous (V) chloride, however exist as an ionic solid due to the presence of the ions $[PCl_4]^+$ and $[PCl_6]^-$.

(i) Draw the structures of the cation, $[PCl_4]^+$ and anion, $[PCl_6]^-$. State the shapes of the two ions.

[3]

(ii) Silicon tetrachloride reacts readily with water but carbon tetrachloride does not hydrolyse readily. Explain.

……

……

[1]

(iii) Suggest another physical property that is different between silicon tetrachloride and phosphorous (V) chloride.

……

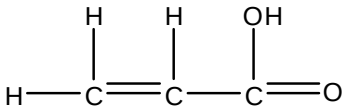
……

[1]

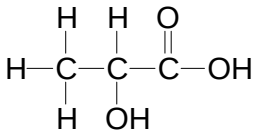
[Total: 12 marks]

For Examiner's use

3 (a) (i) Compound **M**, shown below, reacts with hydrogen bromide. Describe the mechanism for the reaction.



(ii) Compound **M** can be chemically converted into compound **N**, shown below:



Compound **N**, is found in muscle tissues as lactic acid and is optically active whereas when it is chemically synthesised it is optically inactive. Explain.

……

……

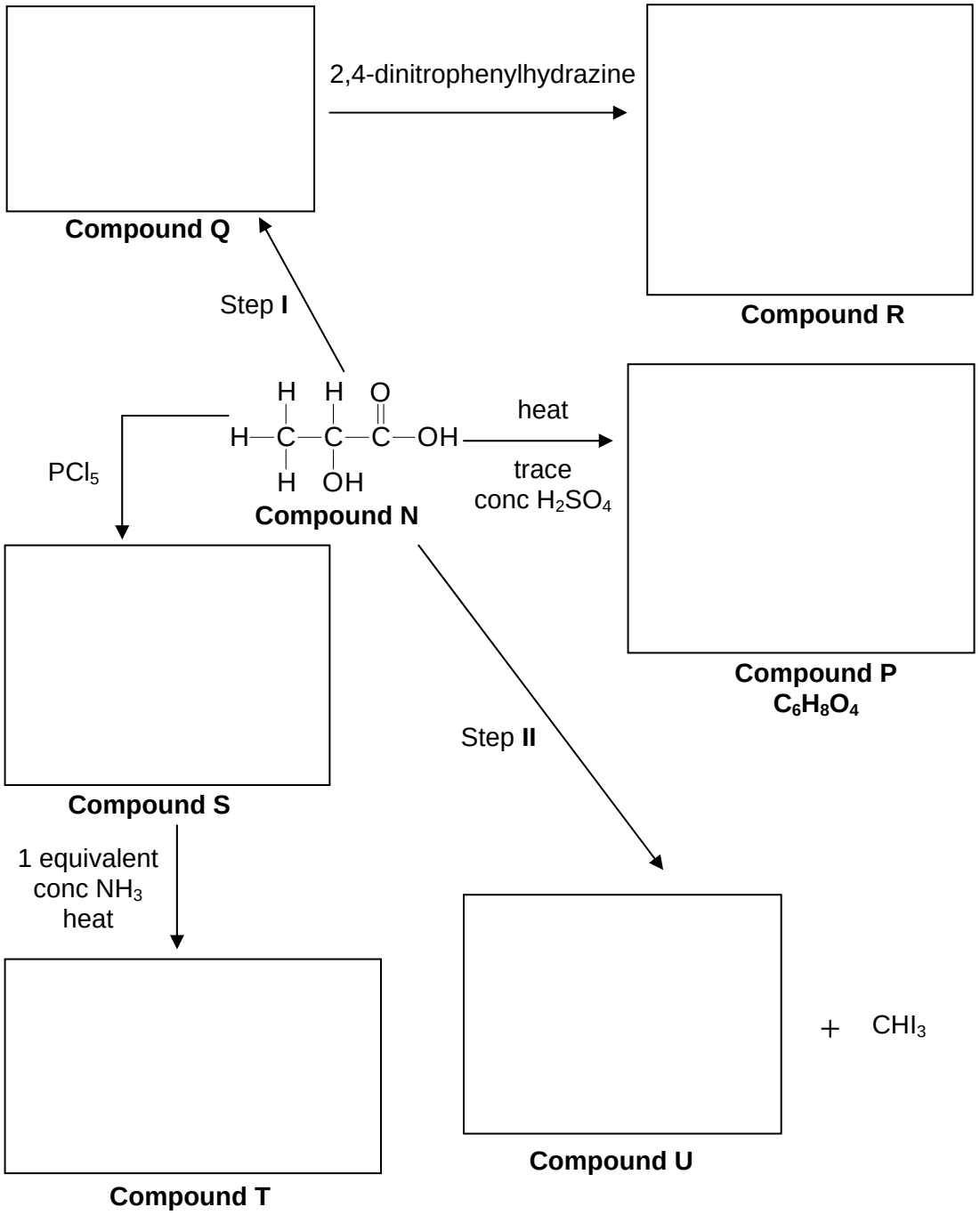
……

……

[4]

For Examiner's use

(b) **(i)** The flow scheme below concerns the reactions of compound **N**. Draw the structures of the organic compounds **P** to **U** in the boxes provided.



(ii) State the reagents and conditions for Step **I** and Step **II**.

Step **I**: ……

Step **II**: ……

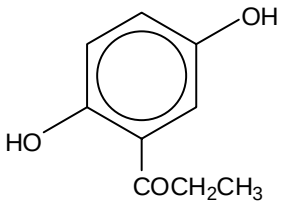
[8]

[Total: 12 marks]

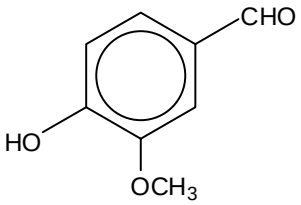
For Examiner's use

4 Suggest how the following compounds could be distinguished from each other by chemical tests. For each test, state the reagents and conditions you would use, the observations you would make with **each** compound undergoing the test and write balanced equations for the reactions.

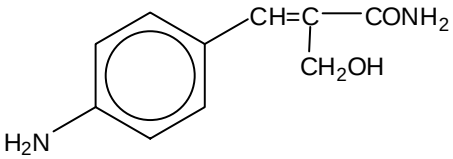
(a)



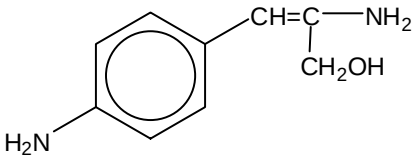
and



(b)



and



[6]
[Total: 6 marks]

For Examiner's use

5 (a) (i) Explain why magnesium gives the nitride Mg_3N_2 in addition to its oxide when burned in air.

……

……

……

……

[1]

(ii) A 1.00 g sample of the powder obtained from burning magnesium in air was boiled with water. It produced a hydroxide and ammonia. The ammonia that was evolved neutralised 12.0 cm^3 of 0.5 mol dm^{-3} hydrochloric acid.

Write an equation for the action of water on magnesium nitride. Hence calculate the percentage of magnesium nitride in the sample.

[3]

(iii) Suggest a suitable indicator to use for the titration of $NH_3(aq)$ with HCl(aq) in **(a)(ii)**.

……

[1]

13

For Examiner's use

(b) **(i)** Two glass bulbs are connected by a glass tube with a valve. One bulb has a volume of 600 cm^3 and contains $NH_3(g)$ at 41.3 kPa. The other bulb has a volume of 400 cm^3 and contains HCl(g) at 31.0 kPa.

After opening the valve, what will be the equilibrium pressure if temperature is kept constant at 25°C throughout the whole process?

[3]

(ii) Predict whether the actual pressure will be higher or lower than the calculated value in **(b)(i)**. Explain.

……

……

[1]

(c) Describe and explain the trend in the thermal stabilities of the nitrates of Group II elements from Mg to Ba. Write a general equation for the reaction that occurs on heating.

……

……

……

……

……

……

……

[3]

For Examiner's use

(d) Explain why beryllium oxide is amphoteric.

……

[1]

[Total: 13 marks]

6 (a) When a person exercises, the process known as "cell respiration" provides the body with the energy needed. During this process, glucose is 'burnt' in the reaction which is similar to the following complete combustion of glucose.

$$C_6H_{12}O_6\,(s) + 6O_2\,(g) \rightarrow 6CO_2\,(g) + 6H_2O\,(l)$$

(i) The ignition temperature of glucose is approximately 800 ^oC. Suggest how the combustion of glucose occurs inside our bodies, where the average body temperature is only 37 ^oC.

……

……

……

……

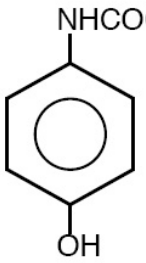
(ii) A person exercising uses energy at an average rate of 240 kJ per hour. Using the data given below, construct **an energy cycle** to calculate the enthalpy change of combustion of glucose. Hence, calculate the mass of glucose that has to undergo combustion to provide this energy for one hour.

$\Delta H_f^o\, CO_2\,(g) = -393$ kJ mol^{-1}
$\Delta H_f^o\, H_2O\,(l) = -285$ kJ mol^{-1}
$\Delta H_f^o\, C_6H_{12}O_6\,(s) = -1248$ kJ mol^{-1}

[6]

For Examiner's use

(b)

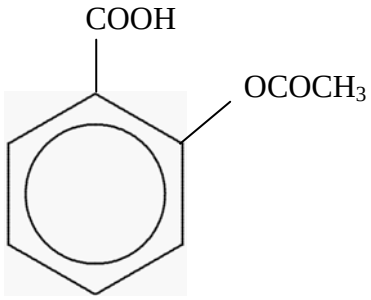


Paracetamol

Paracetamol is used as pain killer.

(i) After paracetamol is refluxed with aqueous sodium hydroxide, draw the products of the resulting mixture.

(ii) Aspirin which has the following structure



is also used to relieve pain. Boiling point of aspirin is lower than paracetamol. Suggest why this is so.

……

……

……

……

……

……

……

[4]

[Total: 10 marks]

For Examiner's use

7 Read through the account of the experiment below and answer the questions that follow.

Test I:
X is a white salt. It decomposes readily on heating to give a colourless odourless gas, which gives white precipitate with limewater, and a white residue.

Test II:
A saturated solution of **X** (sparingly soluble) gives a yellow precipitate with aqueous silver nitrate, which dissolves in dilute aqueous ammonia to give a colourless solution.

Test III:
When solution **X** is treated with dilute nitric acid, followed by aqueous silver nitrate, it gives no precipitate.

Test IV:
A solution of **X** gives a white precipitate with aqueous sodium hydroxide, which remains insoluble in excess aqueous sodium hydroxide.

Test V:
When solution **X** is treated with aqueous ammonia, it gives no precipitate.

(a) Identify the cation and anion in salt **X**.

……..

[2]

(b) Write equations, with state symbols, for **all** the reactions in Test I and Test II.

[4]

(c) Why is there no precipitate in Test III?

……

……

[1]

[Total: 7 marks]

- End of Paper -