AS Level Chemistry B (Salters)

H033/02 Chemistry in depth

Sample Question Paper

Date – Morning/Afternoon

Time allowed: 1 hour 30 minutes

You must have:
- the Data Sheet for Chemistry B (Salters)

You may use:
- a scientific calculator

First name									
Last name									
Centre number						**Candidate number**				

INSTRUCTIONS
- Use black ink. You may use an HB pencil for graphs and diagrams.
- Complete the boxes above with your name, centre number and candidate number.
- Answer **all** the questions.
- Write your answer to each question in the space provided.
- Additional paper may be used if required but you must clearly show your candidate number, centre number and question number(s).
- Do **not** write in the barcodes.

INFORMATION
- The total mark for this paper is **70**.
- The marks for each question are shown in brackets **[ ]**.
- Quality of extended responses will be assessed in questions marked with an asterisk (*).
- This document consists of **16** pages.

Answer **all** the questions.

1 Some early designed periodic tables attempted to arrange the known elements in a pattern that showed trends in chemical properties.

One version, shown for the first 17 elements in **Fig. 1.1**, was produced by the English chemist John Newlands. This shows the elements thought to exist at the time.

H 1	F 8	Cl 15
Li 2	Na 9	K 16
G 3	Mg 10	Ca 17
Bo 4	Al 11	
C 5	Si 12	
N 6	P 13	
O 7	S 14	

Fig. 1.1

(a) Newlands gave the elements a 'position number' as shown in **Fig. 1.1**.

What do we call 'position number' today?

……. **[1]**

(b) Newland's periodic table and a later version by Mendeleev were arranged by atomic weight (relative atomic mass).
The existence of isotopes was not known and therefore atomic weights were not as accurate as today. Nickel and cobalt were given the same atomic weight of 59.

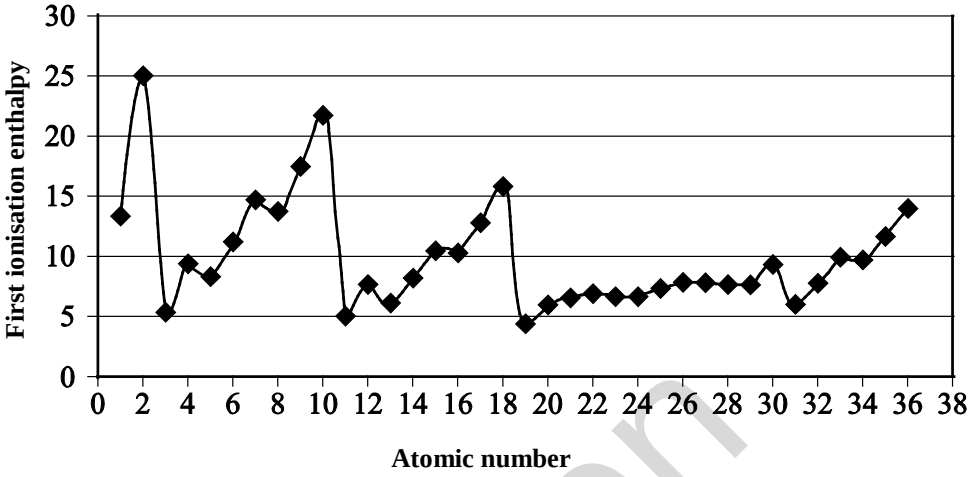
Use the isotopic abundance data below to obtain a value for the atomic weight (relative atomic mass) of nickel to an **appropriate** number of significant figures.

Isotope	^{58}Ni	^{60}Ni	^{61}Ni	^{62}Ni	^{64}Ni
% by mass	68.1	26.2	1.14	3.63	0.930

atomic weight of nickel = **……** **[2]**

(c) Another chemist, Lothar Meyer, worked at the same time as Mendeleev. His main contribution was the recognition of *periodic behaviour*, i.e. a repeating pattern of a property shown on a graph.

The graph below shows the repeating pattern of first ionisation enthalpy for elements in the modern periodic table.



(i) Circle **all** the points on the graph above which represent the first ionisation enthalpies of the **Period 2** elements.

[1]

(ii) Ignoring the small drops mid-period, explain why the first ionisation enthalpies broadly increase across Period 2.

……

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…… **[3]**

(d) During a flame test, blue light was emitted with a wavelength of 400 nm.

Calculate the energy change of this emission.

Include units in your answer.

Energy change **……** **[4]**

(e) Magnesium hydroxide is useful as an antacid in some indigestion tablets.

A typical antacid tablet contains 0.292 g of magnesium hydroxide, $Mg(OH)_2$.

A student decides to calculate the volume of stomach acid that the tablet can neutralise. Assume the stomach contains hydrochloric acid of concentration 0.10 mol dm^{-3}.

The equation for the neutralisation reaction is:

$$Mg(OH)_2(s) + 2HCl(aq) \rightarrow MgCl_2(aq) + 2H_2O(l)$$

What volume of stomach acid can the tablet neutralise?

volume of acid = …… cm^3 **[2]**

(f) Some students are given a drain cleaner that is described as '50% NaOH solution'. They are told that this means that roughly 50 g NaOH are dissolved in 100 cm^3 solution.

The students have a standard 0.300 mol dm^{-3} solution of HCl and they wish to use this to find the accurate concentration of the drain cleaner.

The students accurately dilute a certain volume of the drain cleaner to 1000 cm^3.

(i) Calculate the volume of drain cleaner the students need to dilute to get a suitable solution for titration with the acid.

volume = …… cm^3 **[3]**

(ii) Suggest the apparatus used by the students to dilute the drain cleaner.

……

…… **[1]**

2 Butene, C_4H_8, is a minor component in crude oil. Butene is used in co-polymerisation with other monomers to form hot melt adhesives.

(a) There are structural isomers of C_4H_8. One of the structural isomers is but-2-ene.

But-2-ene is an isomer of C_4H_8 that exhibits stereoisomerism.

Draw the structures of both stereoisomers of but-2-ene and give their systematic names.

name: **……**

name: **…….** **[2]**

(b) Butane, another four carbon hydrocarbon, is used as fuel in cordless hair straighteners.

(i) Write an equation for the complete combustion of 1 mol of butane.

[1]

(ii) Calculate the volume of oxygen (measured at room temperature and pressure) that would combine with 1.0 g of butane.

volume = …… **[2]**

(iii) 2.15 dm^3 of an unknown gas had a mass of 5.2 g at 18 ^oC and a pressure of 101 kPa.

Calculate the relative molecular mass of the gas and suggest what gas it could be.

Name of gas: …… **[3]**

(iv)* Platinum is used as a heterogeneous catalyst in cordless hair straighteners.

Describe a simple model to illustrate how a substance such as platinum can act as a catalyst. Include a definition of the terms *heterogeneous* and *catalyst* in your answer.

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…… **[6]**

3 Oxides of nitrogen, NO_x, are important trace species in the atmosphere.

Nitrogen monoxide, NO, is a product of the combustion of fuels.

Nitrogen monoxide is formed by the following reaction at high temperatures in car engines.

$$N_2(g) + O_2(g) \rightarrow 2NO(g) \qquad \textbf{Equation 3.1}$$

(a) The rate of this reaction varies with temperature.

Explain why the rate of a reaction decreases as a result of a decrease in temperature.

……

……

…… **[2]**

(b) Nitrogen monoxide, NO, reacts with oxygen as below.

$$2NO(g) + O_2(g) \rightleftharpoons 2NO_2(g) \qquad \Delta_r H = -114 \text{ kJ mol}^{-1} \qquad \textbf{Equation 3.2}$$

(i) Describe and explain the effect, if any, of the following changes on the equilibrium concentration of nitrogen monoxide, giving a reason in each case.

- Increasing the pressure at constant temperature.
- Increasing the temperature at constant pressure.

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…… **[4]**

(ii) A mixture of NO and O_2 is left to reach equilibrium.

The equilibrium concentrations of NO and O_2 are shown below.

[NO(g)] / mol dm^{-3}	**[O_2(g)] / mol dm^{-3}**
0.42	1.70

The value of K_c is 8.54 dm^3 mol^{-1}.

Calculate the equilibrium concentration of NO_2(g).

equilibrium concentration of NO_2(g) = **……** mol dm^{-3}. **[3]**

(iii) Use the expression for K_c to explain how the position of this gaseous equilibrium would change if some of the NO_2 was removed, assuming the overall temperature remained constant.

……

…… **[2]**

(iv) Draw a labelled enthalpy profile for the forward reaction in **Equation 3.2.**

Show the enthalpy change of reaction, $\Delta_r H$, and the activation enthalpy, E_a.

[3]

(c) NO reacts with water. One of the products is compound **A**.

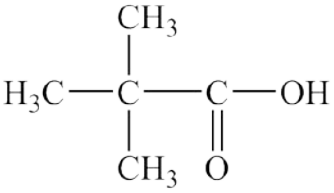
Compound **A** contains H: 2.13%; O: 68.1%.

Calculate the empirical formula of compound **A**.

Show your working.

empirical formula = …… **[2]**

4 Pivalic acid, 2,2-dimethylpropanoic acid, is a white solid used in the production of high quality lacquers.

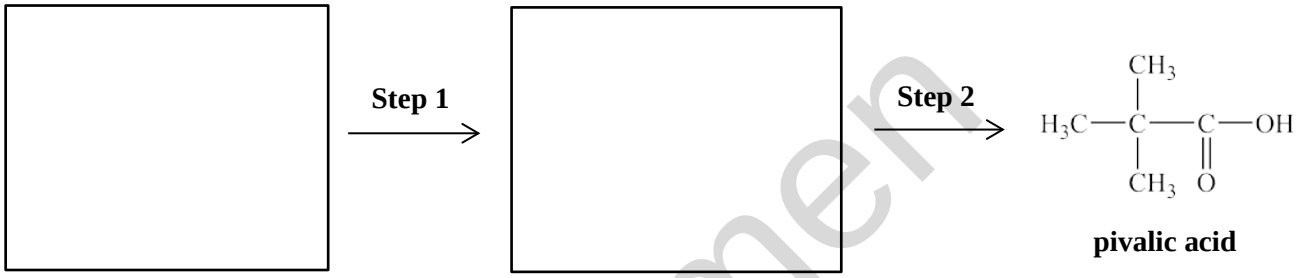


pivalic acid

(a) A student suggests making pivalic acid from 1-bromo-2,2-dimethylpropane in a two-step synthesis.

Write suitable structures in the boxes below to complete the flow diagram.

Give the reagents and conditions for each step.



1-bromo-2,2-dimethylpropane

pivalic acid

Step 1:

reagents and conditions: ……

Step 2:

reagents and conditions: ……

[5]

(b) A student attempted the above synthesis and wanted to test the purity of the pivalic acid that had been made. The student decided to use thin layer chromatography (TLC).

(i) Discuss how appropriate TLC is as a technique for the student's test.

……

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……

…… **[2]**

(ii) The student tells another student that he will take the TLC plate out of the solvent and examine the spotting pattern.

The other student says he should also stand his dried TLC plate in iodine vapour when chromatography is completed.

Comment on both students' statements.

……

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…… **[2]**

(iii) A student is asked to prepare 9.45 g of pivalic acid (M_r = 102) starting from 1-bromo-2,2-dimethylpropane (M_r = 150.9).

The student follows an experimental method for this preparation which has a percentage yield of 37.0%.

Calculate the mass of 1-bromo-2,2-dimethylpropane that the student needs to use.

Give your answer to **three** significant figures.

required mass = …… g **[3]**

(iv) Suggest **two** reasons why the percentage yield is relatively low.

……

……

…… **[2]**

(c) The student took the melting point of the pivalic acid that had been prepared.

(i) A student said that if the pivalic acid was impure it would melt over a range of temperatures above the melting point of pure pivalic acid.

Comment on the student's statement.

……

……

…… **[2]**

(ii) What technique should the student have planned to use in the synthesis in order to improve the purity of the product?

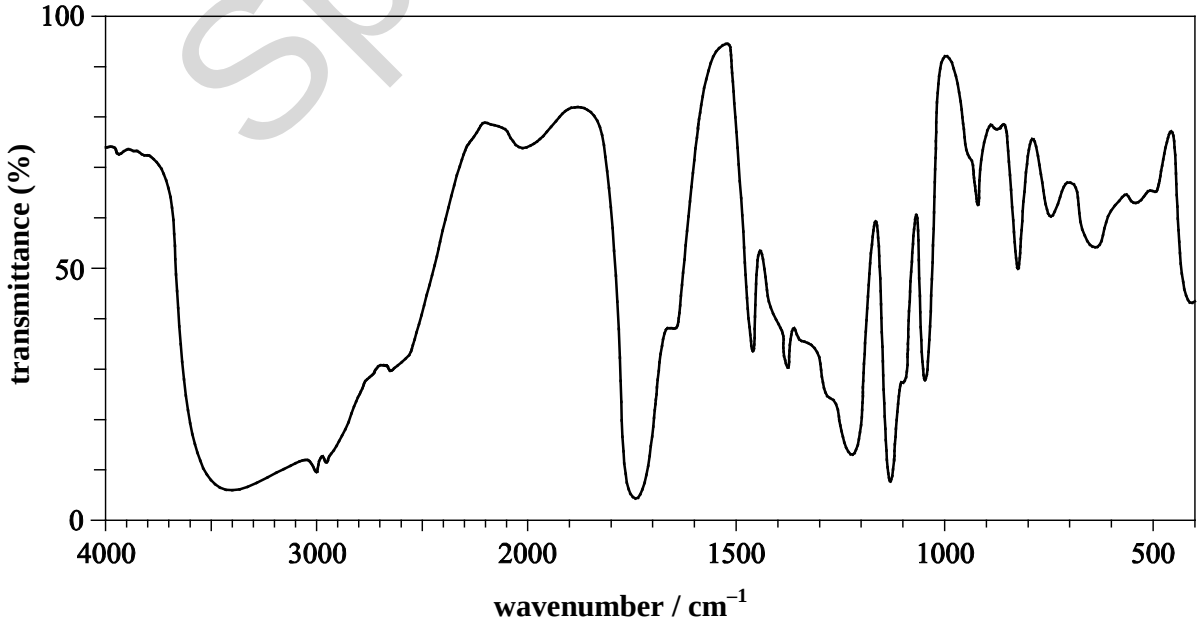
…… **[1]**

(d)* A combination of mass spectrometry and infrared spectroscopy can be used to determine whether pure pivalic acid has been made.

Spectroscopic data for the final product mixture are shown below.

Mass spectrum information for product mixture	
Peak	***m*/*z* ratio**
Base peak	57
Peak of largest *m*/*z*	102

IR spectrum of product mixture:



The student claimed that the combination of the mass spectrum information and the IR spectrum show that pure pivalic acid had been made.

Analyse the evidence from the IR spectra (use the *Data Sheet*), the mass spectrum data and the nature of the compounds involved in the synthesis to comment on the validity of the student's claim.

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…… **[6]**

END OF QUESTION PAPER