NATIONAL JUNIOR COLLEGE

SH 1 PROMOTIONAL EXAMINATIONS

Higher 1

CANDIDATE NAME			
SUBJECT CLASS		REGISTRATION NUMBER	

CHEMISTRY 8873/02

Paper 2 Structured Questions

Tues 1 Oct 2019

Additional Materials: Data Booklet

1 hour 30 min

READ THE INSTRUCTIONS FIRST

Write your name, subject class and registration number on all the work you hand in.
Write in dark blue or black ink on both sides of the paper.
You may use a soft pencil for any diagrams or graphs.
Do not use paper clips, highlighters, glue or correction fluid.

Structured Questions
Answer **ALL** questions on the question paper.

The use of an approved calculator is expected where appropriate.
A Data Booklet is provided.

The number of marks is given in brackets [ ] at the end of each question or part question.
Appropriate significant figures and units are expected for final numerical answers.

For Examiner's Use	
1	/7
2	/4
3	/5
4	/14
5	/7
6	/5
7	/10
8	/8
Penalty	
s.f.	
units	
Total	**/60**

This document consists of **15** printed pages and 1 blank page.

Answer **ALL** questions in the space provided.

For Examiner's Use

1 (a) A sample of lead contains four stable isotopes with the following percentage abundances.

Isotope	Percentage abundance / %
^{204}Pb	1.4
^{206}Pb	24.1
^{207}Pb	22.1
^{208}Pb	**a**

(i) Define the term *relative atomic mass*.

……

……

[1]

(ii) Determine the value of **a**.

Hence calculate the relative atomic mass of lead. Give your answer to two decimal places.

[2]

(iii) Bismuth is on the right side of lead in the Periodic Table.

Predict and explain whether bismuth has a higher or lower first ionisation energy compared to lead.

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……

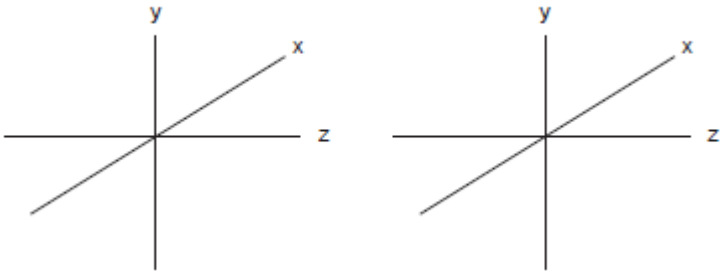
……

[2]

For Examiner's Use

(b) When the atomic orbitals from two atoms overlap a chemical bond may result. The p orbitals can overlap to form sigma (σ) or pi (π) bonds. When two atoms overlap the *z*-axis is used to define the internuclear axis.

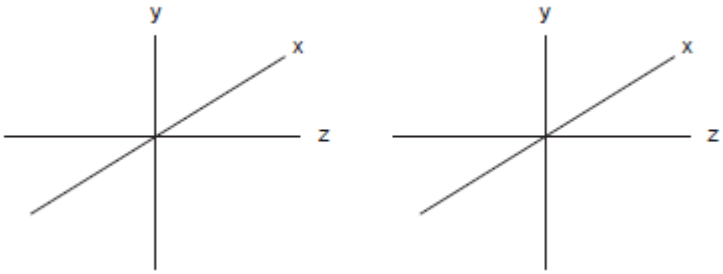
(i) On the diagram below draw two p orbitals (one orbital on each atom) that could overlap to produce a sigma (σ) bond.



atom 1 atom 2

[1]

(ii) On the diagram below draw two p orbitals (one orbital on each atom) that could overlap to produce a **single** pi (π) bond.



atom 1 atom 2

[1]

[Total: 7]

For Examiner's Use

2 One means of measuring toxicity is using LD, which stands for "Lethal Dose". LD_{50} is the amount of a material which causes the death of 50% of a group of test animals. LD_{50} value is expressed as the mass of a chemical administered per kg body mass of a test animal.

Another means of measuring toxicity is using LC, which stands for "Lethal Concentration". The concentration of the chemical in air that kills 50% of the test animals during the observation period is the LC_{50} value.

The table below shows the values for the LD_{50} and LC_{50} along with the toxicity ratings.

(1 g = 1000 mg)

Toxicity Rating	Commonly used term	LD_{50}: Oral (mg kg^{-1})	LC_{50}: Inhalation (ppm)
1	Extremely Toxic	1 or less	10 or less
2	Highly Toxic	>1 – 50	11– 100
3	Moderately Toxic	51 – 500	101 – 1000
4	Slightly Toxic	501 – 5000	1001 – 10,000
5	Practically Non-toxic	5001 – 15,000	10,001 – 100,000

(i) 4.45×10^{-4} mol of a toxic compound, C_4H_5NO, was found to cause death in 50 % of test animals weighing 1 kg.

Calculate LD_{50} of the compound and state its toxicity rating.

Toxicity rating:……

[2]

For Examiner's Use

(ii) Phosphine gas, PH_3, is widely used in the semi-conductor industry as a dopant.
The concentration of a small quantity of gas is usually expressed in parts per million (ppm) as shown below:

$$\text{Concentration in ppm} = \frac{\text{volume of gas}}{\text{volume of air}} \times 10^6$$

Given that LC_{50} for PH_3 is 200 mg m^{-3} at room temperature and pressure, convert LC_{50} to ppm and determine its toxicity rating.

Toxicity rating:……

[2]
[Total:4]

3 **(a)** Some bacteria can oxidise methane to carbon dioxide in the absence of oxygen. It has recently been reported that the mechanism involves a reaction between methane and nitrite ions in acidic conditions (reported in *Nature*, 2010).

The half-equation for the oxidation of methane is:

$$CH_4 + 2H_2O \rightarrow CO_2 + 8H^+ + 8e^-$$

(i) Write a half-equation for the reduction of NO_2^- in acidic conditions to give N_2.

……..[1]

(ii) By combining the half-equations, or otherwise, balance the overall equation shown below.

.....CH_4 + ...NO_2^- + ...$H^+ \rightarrow$ .....CO_2 + ...N_2 + ... H_2O [2]

(iii) Identify the oxidising agent in the reaction in **(ii)**. Justify your answer using oxidation numbers.

……..

……..

[2]
[Total:5]

4 Hematite is a common iron oxide with the formula Fe_2O_3. It is a very important naturally occurring compound that finds widespread use as a heterogeneous catalyst. Fe_2O_3 is used in the Haber Process which combines nitrogen with hydrogen into ammonia.

For Examiner's Use

$$N_2\,(g) + 3\,H_2\,(g) \rightleftharpoons[Fe_2O_3] 2\,NH_3\,(g)$$

(a) (i) What is meant by the term ***heterogeneous*** catalyst?

……

……

[1]

(ii) State the three stages involved in a typical reaction involving a heterogeneous catalyst.

1. .....

2. .....

3. .....

[2]

(iii) With the aid of a Boltzman distribution curve, explain how Fe_2O_3 affect the rate of the Haber Process.

……

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……

……

[3]

(b) Fe_2O_3 can also react with CO to produce Fe.

For Examiner's Use

$$Fe_2O_3(s) + 3CO(g) \rightarrow 2Fe(s) + 3CO_2(g) \qquad \Delta H_r = -27 \text{ kJ mol}^{-1}$$

(i) Draw a labelled reaction pathway diagram for this reaction, given that the activation energy of the reaction is 37 kJ mol^{-1}.

[2]

(ii) Hence, or otherwise, determine the activation energy for the following reaction.

$$2Fe(s) + 3CO_2(g) \rightarrow Fe_2O_3(s) + 3CO(g)$$

[1]

(iii) Draw a dot-cross diagram to show the bonding in Fe_2O_3. Show outer electrons only.

[1]

(c) **(i)** Iron is a metal.
Describe the bonding in the element iron. Draw a diagram to illustrate your answer.

For Examiner's Use

……

……

……

[2]

(ii) State two physical properties that you would expect iron metal to possess. Explain, in terms of the bonding present, why it possesses these properties.

Property……

Explanation ..……

……

Property……

Explanation ..……

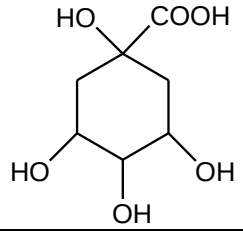
……

[2]

[Total: 14]

5 Pure natural acids can be extracted from roasted coffee. Some are

For Examiner's Use

$CH_3CH(OH)CO_2H$	$HO_2CCH=CHCO_2H$	CH_3COCO_2H	
Lactic acid	Maleic acid	Pyruvic acid	Quinic acid

(a) Other than the carboxylic acid functional group, what other functional groups are also present in these natural acids?

Lactic acid: ……

Maleic acid: ……

Pyruvic acid: ……

[2]

(b) Quinic acid can be expressed as the condensed formula, $C_xH_yO_z$.
State the values for x, y and z.

x: …… y: …… z:……

[1]

(c) Maleic acid can exhibit stereoisomerism.

State the type of stereoisomerism exhibited and draw the isomers.

[2]

(d) Lactic acid is able to react with aqueous NaOH in a neutralisation reaction. However, the standard enthalpy change of neutralisation between lactic acid and aqueous NaOH has a smaller magnitude compared to that between hydrochloric acid and aqueous NaOH. Explain this observation.

For Examiner's Use

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[2]

[Total:7]

6 **(a)** The kinetics of the reaction between 1-bromobutane and hydrogen sulfide ions (HS^-) was studied and the following results were obtained.

Initial concentration of 1-bromobutane /mol dm^{-3}	Initial concentration of HS^- /mol dm^{-3}	Initial rate of reaction /mol dm^{-3} s^{-1}
0.1	0.1	1.5×10^{-5}
0.2	0.1	3.0×10^{-5}
0.3	0.2	9.0×10^{-5}
x	y	4.5×10^{-5}

(i) Deduce the orders of reaction with respect to 1-bromobutane and HS^- ions.

[2]

(ii) Hence write the rate equation ~~and determine the rate constant of the reaction.~~

[2]

(iii) Suggest a set of values for x and y.

[1]

[Total:5]

7 The elements in Group 17, the halogens, and their compounds, show many similarities and trends in their properties. The table below shows the boiling points for the hydrogen halides for the elements, fluorine to iodine.

For Examiner's Use

Hydrogen halide	Boiling point / K
HF	293
HC*l*	188
HBr	206
HI	238

(a) Explain the trend in the boiling points of the hydrogen halides, HF, HC*l*, HBr and HI.

……

……

……

……

[3]

(b) **(i)** Butane can react with chlorine to form 2–chlorobutane.

Draw the skeletal structure of 2–chlorobutane.

[1]

(ii) Predict and explain whether 2-chlorobutane or $(CH_3)_3CCl$ has a higher boiling point.

……

……

……

[2]

(c) Ethane and chlorine are able to react as shown below.

For Examiner's Use

$$C_2H_6(g) + 2Cl_2(g) \rightarrow C_2H_4Cl_2(g) + 2HCl(g)$$

(i) Using the *Data Booklet*, determine the enthalpy change of reaction for the reaction between ethane and chlorine.

[2]

(ii) Draw all the possible isomers for $C_2H_4Cl_2$ and state the type of isomerism exhibited.

[2]

[Total: 10]

8 Magnesium powder is used to generate heat for battlefield soldiers wanting a hot drink. 9.0 g of magnesium powder is added to 30.0 g of water.

For Examiner's Use

$$Mg + 2H_2O \rightarrow Mg(OH)_2 + H_2$$

(i) Calculate the volume of hydrogen gas, in dm^3, produced at room temperature and pressure.

[2]

(iii) Using the data in the table below, calculate the standard enthalpy change of reaction for magnesium reacting with water.

substance	$\Delta H_f^{\ominus}$/ kJ mol^{-1}
H_2O	−285.8
$Mg(OH)_2$	−924.5

[2]

(iv) Calculate the heat energy, in kJ, released when 9.0 g of magnesium powder is added to 30.0 g of water.

[1]

For Examiner's Use

(v) When the magnesium powder and water are mixed, the temperature of the drink being heated can rise to 60 °C in about 10 minutes.

Calculate how much energy, in kJ, is required to heat 150 g of the drink from 15 °C to 60 °C. Assume that the specific heat capacity of the drink is 4.2 J $g^{-1}K^{-1}$.

[1]

(vi) How would using 9.0 g of magnesium **granules** affect the amount of energy released and the temperature reached of the drink in about 10 minutes? Explain your answer.

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[2]

[Total: 8]

End of Paper

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