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YEAR 12 *Trial Exam Paper*
2019
CHEMISTRY
Written examination

Reading time: 15 minutes
Writing time: 2 hours 30 minutes

STUDENT NAME:

QUESTION AND ANSWER BOOK

Structure of book

Section	*Number of questions*	*Number of questions to be answered*	*Number of marks*
A	30	30	30
B	10	10	90
			Total 120

- Students are permitted to bring the following into the examination room: pens, pencils, highlighters, erasers, sharpeners, rulers and one scientific calculator.
- Students are NOT permitted to bring into the examination room: blank sheets of paper and/or correction fluid/tape.

Materials provided
- Question and answer book of 31 pages
- Data book
- Answer sheet for multiple-choice questions

Instructions
- Write your **name** in the box provided.
- Unless otherwise indicated, the diagrams in this book are **not** drawn to scale.
- All written responses must be in English.

At the end of the examination
- Place the answer sheet for multiple-choice questions inside the front cover of this book.
- You may keep the data book.

Students are NOT permitted to bring mobile phones and/or any other unauthorised electronic devices into the examination.

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SECTION A – Multiple-choice questions

Instructions for Section A

Answer **all** questions in pencil on the answer sheet provided for multiple-choice questions.

Choose the response that is **correct** or that **best answers** the question.

A correct answer scores 1, an incorrect answer scores 0.

Marks will **not** be deducted for incorrect answers.

No marks will be given if more than one answer is completed for any question.

Unless otherwise indicated, the diagrams in this book are **not** drawn to scale.

Question 1

Which one of the following is the **most** accurate description of a renewable fuel?

A. a fuel that is consumed at the same rate as it is produced

B. a fuel that has unlimited reserves

C. a fuel that can be replenished at a sustainable rate

D. a fuel that is completely recyclable

Question 2

Victoria produces around 200 petajoules of energy from natural gas each year, with one petajoule equal to 10^{15} joules.

Assuming natural gas is pure methane, what mass of methane gas is consumed to produce this amount of energy?

A. 3.6×10^{12} g

B. 3.6×10^{12} kg

C. 3.6×10^{15} g

D. 5.6×10^{15} g

Question 3

One of the most important uses for alkanes is as fuels. Their combustion reactions with oxygen are very exothermic.

Which one of the following statements about the energy density trend in the alkane series is correct?

A. Liquid alkanes will release more energy per gram than gaseous alkanes.

B. Each alkane releases the same amount of energy per gram.

C. The energy density increases as the carbon to hydrogen ratio increases.

D. The energy density decreases as the carbon to hydrogen ratio increases.

Question 4

A general equation for the production of biodiesel from a triglyceride is

A. 3triglyceride → 3biodiesel + glycerol.

B. triglyceride + 3methanol → 3biodiesel + glycerol.

C. triglyceride + methanol → biodiesel + 3glycerol.

D. 3triglyceride + 3methanol → biodiesel + glycerol.

Question 5

The complete combustion of 0.08 mol of a particular fuel is found to require 0.28 mol of oxygen gas.

The fuel is likely to be

A. methane.

B. ethane.

C. ethanol.

D. butane.

Question 6

The heats of combustion values for methane and diesel indicate that each gram of methane can release significantly more energy than each gram of diesel. A car is fitted with a 50 litre fuel tank and modified to run on diesel. An identical car is fitted with a 50 litre fuel tank and modified to run on methane. The fuel tank of each car is filled with the relevant fuel and the car is driven until its fuel tank is empty. It is found that the car running on diesel travels 140 km further than the car running on methane.

The most likely reason the car running with diesel travels further is that the

A. energy density of diesel is greater at the temperature of a combustion engine.

B. activation energy of methane is much higher than that of diesel.

C. car running on methane is not correctly tuned.

D. density of methane is significantly less than that of diesel.

Use the following information to answer Questions 7 and 8.

Nitrosyl chloride, NOCl, is a gas that can decompose to form nitrogen monoxide gas and chlorine gas. The equation for the reaction is

$$2NOCl(g) \rightleftharpoons 2NO(g) + Cl_2(g)$$

Question 7

A sample of NOCl is added to an empty reactor.

When equilibrium is reached, the

A. number of moles of nitrosyl chloride will be double that of chlorine.

B. number of moles of nitrosyl chloride will equal that of nitrogen monoxide.

C. number of moles of nitrogen monoxide will be double that of chlorine.

D. number of moles of nitrogen monoxide will be half that of chlorine.

Question 8

In another equilibrium mixture of the three gases, the concentrations of the three gases are all found to be equal. The value of the equilibrium constant at that temperature is 0.2 M.

The concentration of each gas, in M, must be

A. 0.008

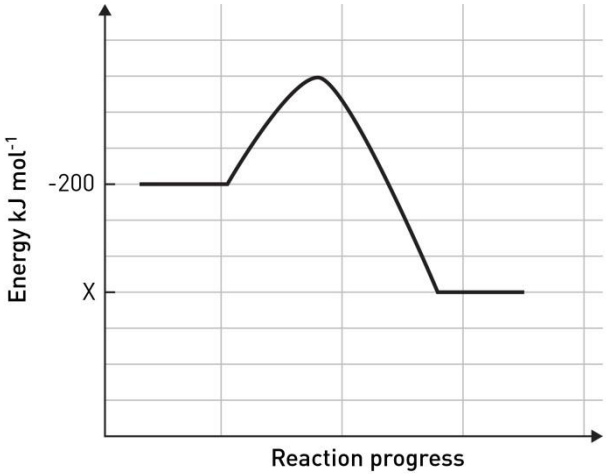
B. 0.04

C. 0.2

D. 0.1

Question 9

The energy profile diagram shown below represents the complete combustion of methane.



The value of X on the vertical axis will be

A. +690 kJ mol^{-1}

B. –690 kJ mol^{-1}

C. –890 kJ mol^{-1}

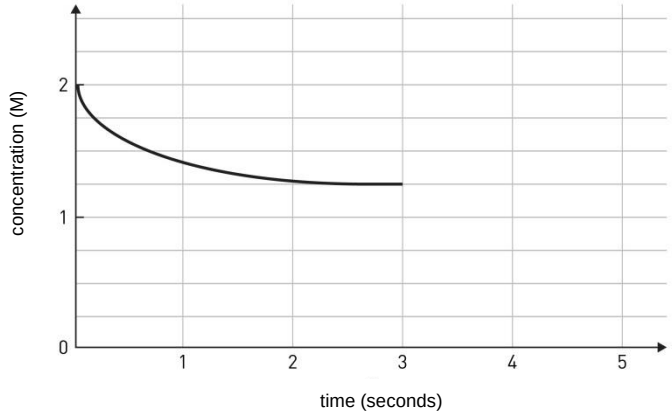
D. –1090 kJ mol^{-1}

Question 10

Hydrogen iodide gas decomposes according to the following equation.

$$2HI(g) \rightleftharpoons H_2(g) + I_2(g)$$

A sample of HI is added to an empty reactor and its concentration is monitored on the graph below.



The value of the equilibrium constant for this reaction will be

A. 8.89

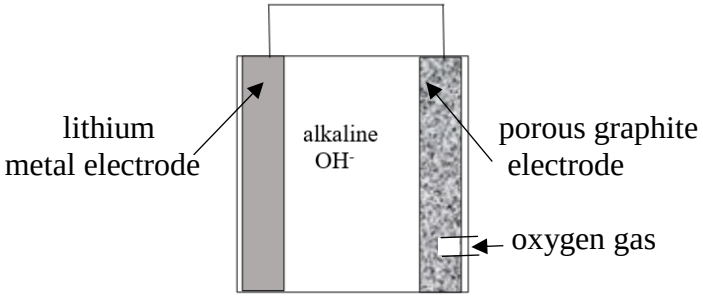
B. 1.0

C. 0.113

D. 0.090

Use the following information to answer Questions 11 and 12.

Lithium batteries are the subject of considerable research. Lithium offers a unique combination of light weight and high voltage that is very attractive to both car manufacturers and electricity providers. One of the variations being researched is the lithium–air cell, which is outlined below. The cell operates in an alkaline environment.



The overall equation for this cell is shown below.

$$4Li(s) + O_2(g) + 2H_2O(l) \rightarrow 4LiOH(aq)$$

Question 11

The cathode reaction occurring in this cell is

A. $O_2(g) + 2H_2O(l) + 4e^- \rightarrow 4OH^-(aq)$

B. $O_2(g) + 4H^+(aq) + 4e^- \rightarrow 2H_2O(l)$

C. $O_2(g) + 4e^- \rightarrow 2O^{2-}(aq)$

D. $Li(s) \rightarrow Li^+(aq) + e^-$

Question 12

During discharge in this cell, the

A. lithium electrode will increase in mass as more lithium forms.

B. electrons will flow from the lithium electrode to the graphite electrode.

C. pH of the cell will drop as OH^- ions form.

D. mass of lithium reacting will be four times that of the oxygen gas.

Question 13

Two experiments are conducted to investigate the rate of reaction between $CaCO_3$ (molar mass = 100.1 g mol^{-1}) and HCl.

Experiment 1 – 1 g of powdered $CaCO_3$ is added to 20 mL of 1.0 M HCl.

Experiment 2 – 2 g of powdered $CaCO_3$ is added to 20 mL of 1.0 M HCl.

In experiment 2

A. gas is evolved at the same rate but twice the volume of gas is evolved.

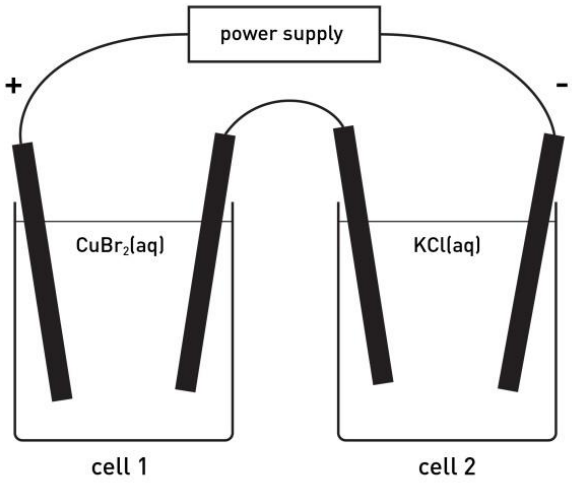
B. gas is evolved at the same rate and the same volume of gas is evolved.

C. gas is evolved faster but the same volume of gas is evolved.

D. gas is evolved faster and twice the volume of gas is evolved.

Use the following information to answer Questions 14 and 15.

A power supply is connected to two cells in series. Cell 1 contains a dilute solution of copper (II) bromide and cell 2 contains a dilute solution of potassium chloride. The power is switched on and a current flows through the circuit.



Question 14

The products formed at the respective electrodes will be

	Cell 1		Cell 2	
	anode	**cathode**	**anode**	**cathode**
A.	oxygen	hydrogen	oxygen	hydrogen
B.	oxygen	hydrogen	chlorine	potassium
C.	bromine	copper	oxygen	hydrogen
D.	copper	bromine	hydrogen	oxygen

Question 15

10 mol of charge passes through the two cells.

The total amount of gas formed at the electrodes (in moles) will be

A. 5

B. 7.5

C. 10

D. 30

Question 16

An organic molecule has an empirical formula of CH_2. It has two different carbon environments when tested using ^{13}C NMR. The molecule forms only one product when it reacts with chlorine gas.

This molecule could be

A. ethane.

B. ethene.

C. but-1-ene.

D. but-2-ene.

Question 17

An unknown organic molecule is tested to see if its functional groups can be identified. The table below shows the results of tests on the molecule.

Test	Result
addition of bromine water	colour of bromine disappears
addition of indicator, then NaOH	nothing at first, then change of colour
addition of acidified $K_2Cr_2O_7$	no change

The testing results indicate the molecule could be

A. but-1-ene.

B. but-3-enoic acid.

C. butan-1-ol.

D. butanoic acid.

Question 18

Which one of the following molecules has geometric isomers?

A. pent-1-ene

B. hex-3-ene

C. 1,1-dichloroethene

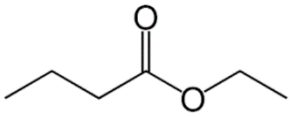
D. 2,3-dichlorobut-1-ene

Question 19

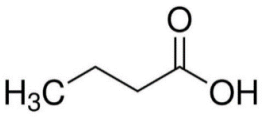
Butyl ethanoate is an ester used as a flavouring in some lollies.

Which one of the following is a skeletal diagram of butyl ethanoate?

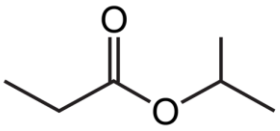
A.



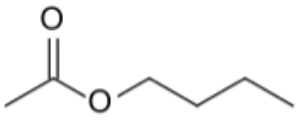
B.



C.



D.



Question 20

A molecule tested using both ^{1}H NMR and ^{13}C NMR is found to have five hydrogen environments and four carbon environments.

This molecule could be

A. butan-2-ol.

B. 2-chlorobutane.

C. pentane.

D. pentan-1-ol.

Question 21

The solvent used in a particular high-performance liquid chromatography (HPLC) column is a mixture of ethanol and water.

Which one of the following molecules is likely to have the longest retention time in this column?

A. butanoic acid

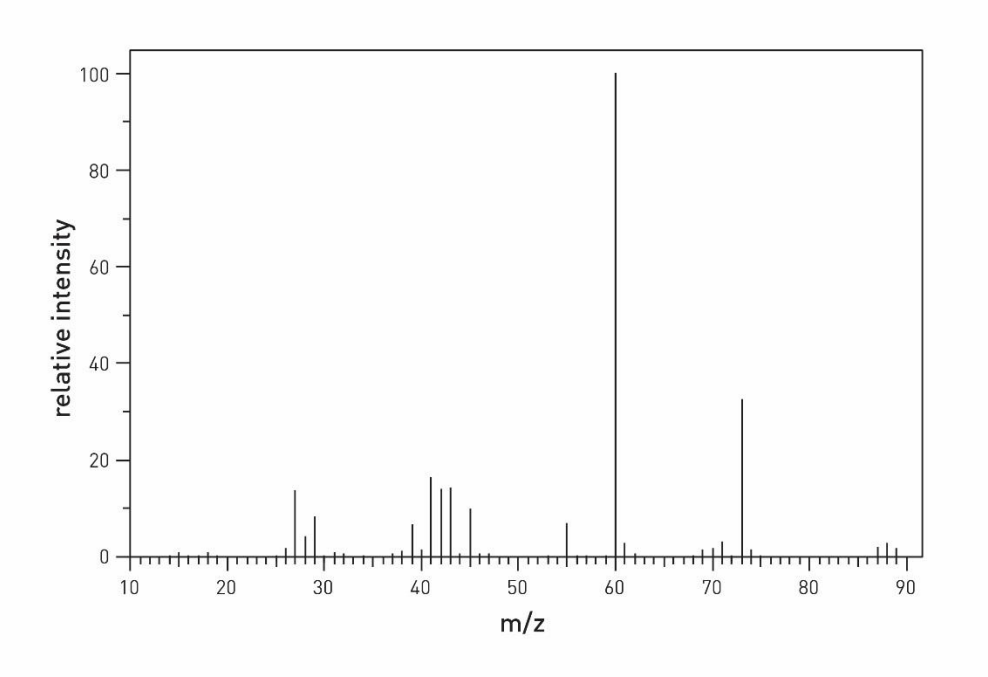
B. butan-1-ol

C. butane

D. hexane

Question 22

An organic molecule has an empirical formula of C_2H_4O. Its mass spectrum is shown below.



Data: SDBS Web, http://sdbs.db.aist.go.jp,
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This molecule could be

A. ethanal.

B. ethanol.

C. butanoic acid.

D. butan-1-ol.

Question 23

The balanced equation for the reaction between dichromate ions and ethanol is

$$3CH_3CH_2OH(aq) + 2Cr_2O_7^{2-}(aq) + 16H^+(aq) \rightarrow 3CH_3COOH(aq) + 4Cr^{3+}(aq) + 11H_2O(l)$$

In a particular experiment, a 200 mL acidified solution of 0.30 M acidified $K_2Cr_2O_7$ changes colour after 450 mL of ethanol is added.

The concentration of the ethanol, in M, is

A. 0.13

B. 0.20

C. 0.23

D. 0.40

Question 24

A compound extracted from wheat has the molecular formula $C_{685}H_{1068}N_{196}O_{211}S_5$.

Which one of the following statements is correct?

A. The molecule is likely to be a vitamin, as it is obviously a large molecule.

B. The molecule is a carbohydrate, and its role is energy storage.

C. The molecule is likely to be one of the forms of starch since it is present in wheat.

D. The molecule is likely to be a protein.

Question 25

Which one of the following could be a dipeptide made from different α-amino acids?

A. $H_2NCH_2CONHCH_2COOH$

B. $H_2NCH_2CONHCH(CH_3)COOH$

C. $H_2NCH_2CH_2CONHCHCH_2COOH$

D. $H_2NCH(OH)CONHCH_2CH(CH_3)COOH$

Question 26

Which one of the following is an omega-3 fatty acid?

A. linolenic acid

B. linoleic acid

C. lauric acid

D. oleic acid

Question 27

The chemical structures of vitamins are varied.

A vitamin is defined as a compound that

A. contains a significant number of hydroxyl functional groups, essential for nutrition.

B. is needed by the body to catalyse a range of digestion reactions.

C. is made in the body but is often supplemented in the diet to prevent disease.

D. is essential for growth and nutrition but is not generally synthesised in the body.

Question 28

Which one of the following is an example of a random error?

A. A 25 mL pipette delivers 25.2 mL.

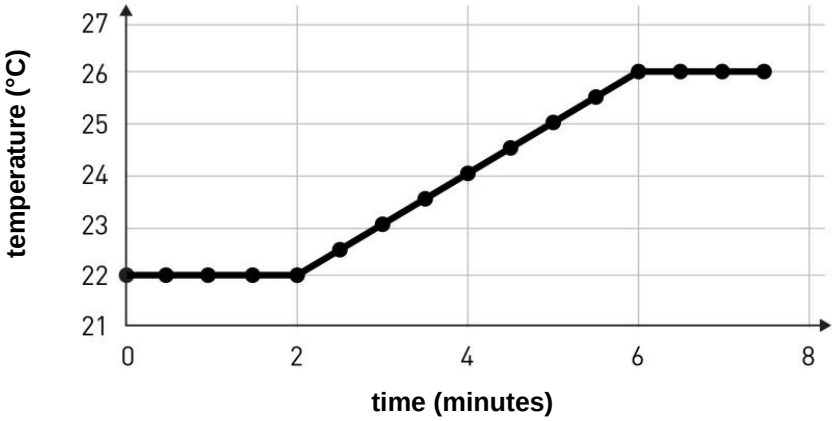
B. Part of an aliquot is spilt during transfer.

C. The temperature of the room fluctuates on a partly cloudy day.

D. The final rinsing of a burette is done with water.

Use the following information to answer Questions 29 and 30.

A bomb calorimeter is used to measure the energy content of foods. Before the experiment is conducted, an electrical current is used to calibrate the calorimeter. The temperature changes recorded are shown on the graph below.



A student uses this calorimeter to measure the heat of combustion of a cashew. Her experimental data are recorded below.

Calibration

Current – 3.60 amperes

Voltage – 5.40 V

Experiment

Mass of cashew – 1.42 g

Initial temperature before combustion – 25.8 °C

Temperature after combustion – 32.6 °C

Question 29

The calibration factor for the calorimeter (in J $°C^{-1}$) will be

A. 292

B. 1170

C. 1280

D. 4320

Question 30

The heat of combustion of the cashew will be

A. 2.00 kJ g^{-1}

B. 2.80 kJ mol^{-1}

C. 5.60 kJ g^{-1}

D. 7.96 kJ mol^{-1}

END OF SECTION A
TURN OVER

SECTION B

Instructions for Section B

Answer **all** questions in the spaces provided. Write using black or blue pen.

Give simplified answers to all numerical questions, with an appropriate number of significant figures; unsimplified answers will not be given full marks.

Show all working in your answers to numerical questions; no marks will be given for an incorrect answer unless it is accompanied by details of the working.

Ensure chemical equations are balanced and that the formulas for individual substances include an indication of state, for example, $H_2(g)$, NaCl(s).

Unless otherwise indicated, the diagrams in this book are **not** drawn to scale.

Question 1 (7 marks)

LPG stands for liquefied petroleum gas. In Australia, LPG is considered to be relatively pure propane. The table below lists some important properties of propane as a fuel.

Properties of propane

density (as LPG)	0.495 g mL^{-1}
boiling point	–42 °C
melting point	–188 °C
pressure of LPG at 40 °C	11.5 atm

a. **i.** What is the value of the pressure, in kPa, in an LPG cylinder at 40 °C?

1 mark

_____

ii. Write a balanced equation for the incomplete combustion of propane, forming carbon monoxide as the only carbon product.

1 mark

_____

b. LPG will usually contain a small amount of sulfur.

Write a balanced equation for the complete combustion of sulfur.

1 mark

_____

c. The volume of a particular LPG (propane) gas cylinder used for camping stoves is 24.0 L.

i. Calculate the mass of propane in the cylinder.

1 mark

_____

_____

ii. Calculate the energy that will be released from the complete combustion of the propane in this cylinder.

1 mark

_____

_____

iii. Calculate the volume of CO_2 that will be released from the combustion at 420 °C and 220 kPa.

2 marks

_____

_____

_____

_____

Question 2 (12 marks)

Fuels can produce energy both thermochemically and electrochemically.

a. Use the table below to list a similarity and a difference between each set of options provided.

6 marks

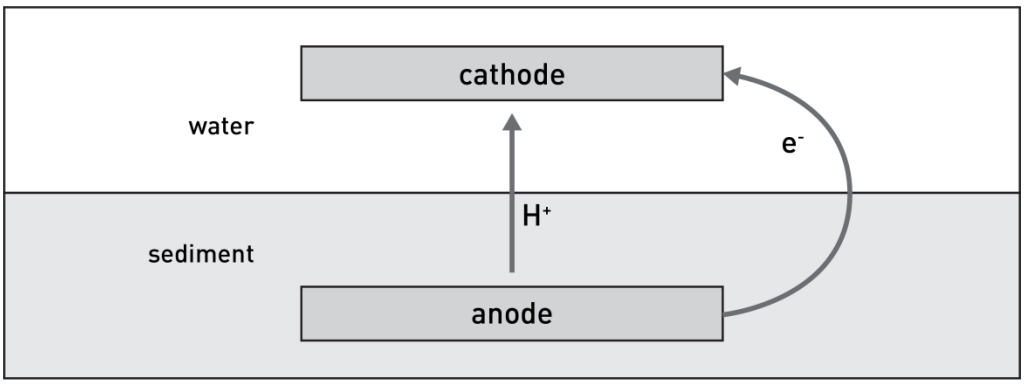
	Similarity	**Difference**
primary galvanic cell compared to a fuel cell		
methane gas in a portable generator compared to a methane fuel cell		
a hydrogen–oxygen fuel cell compared to a cell used to produce sodium from sodium chloride		

b. An ethanol burner is used to heat a can containing 568 g of water. The mass of ethanol that reacts is 1.80 g. The temperature of the water increases from 17.4 °C to 25.6 °C.

Calculate the percentage efficiency of the ethanol burner.

3 marks

c. The diagram below shows an example of a biochemical fuel cell. Electrical energy is produced in these cells from the decomposition of organic waste in acid conditions. In the example below, fermentation leads to the production of ethanoic acid. The ethanoic acid is oxidised in a reaction with the dissolved oxygen gas in the water. The attraction of biochemical cells is that they are using renewable waste material as the reactant.



(sediment organic matter ⟶ ethanoic acid ⟶ CO_2)

fermentation

i. Write a balanced half-equation for the oxidation of ethanoic acid to form CO_2 in acidic conditions.

1 mark

_____

ii. Write a balanced half-equation for the reaction occurring at the cathode.

1 mark

_____

iii. Write an overall equation for the reaction that is occurring.

1 mark

_____

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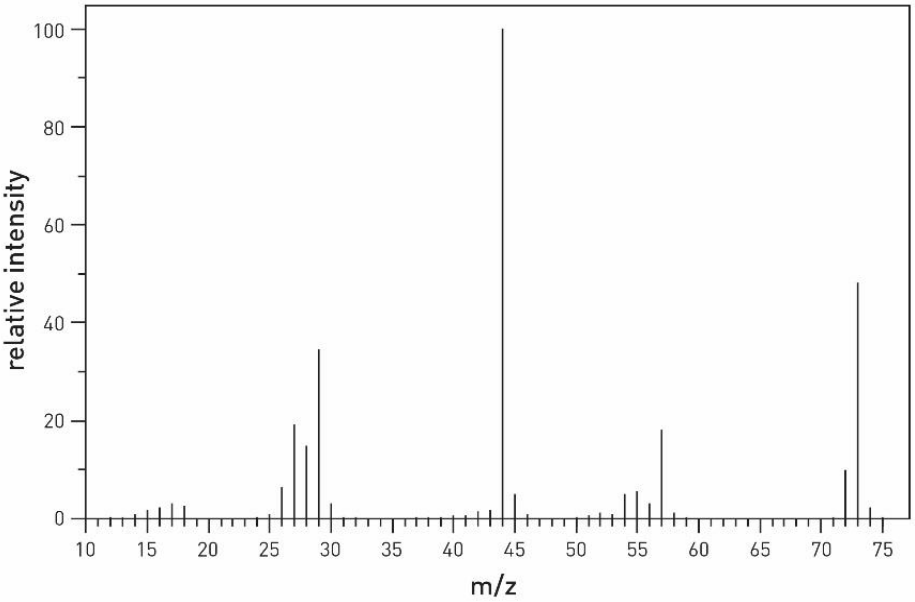
Question 3 (9 marks)

The empirical formula of an organic molecule is found to be C_3H_7ON.

a. The mass spectrum for this molecule is shown below.



Data: SDBS Web, http://sdbs.db.aist.go.jp,
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i. What is the molecular formula of this molecule?

1 mark

_____

_____

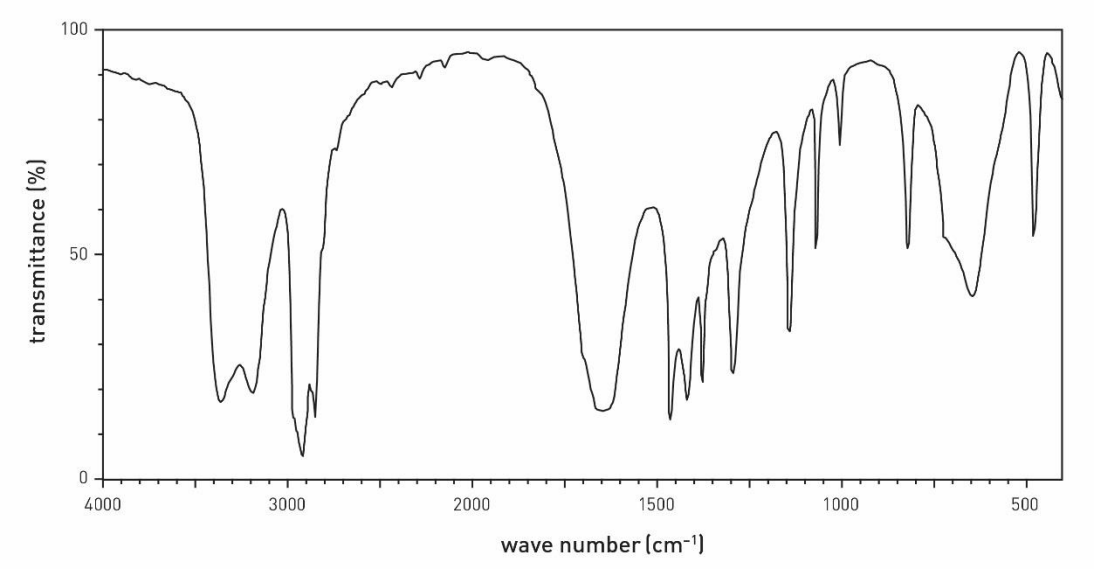
ii. Suggest possible fragments that might be responsible for the peaks with m/z ratios of

2 marks

29 _____

44 _____

b. An infra-red spectrum for this molecule is shown below.



Data: SDBS Web, http://sdbs.db.aist.go.jp,
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Use the table provided to identify two absorptions that will help determine the structure of this molecule.

2 marks

Absorption wavenumber	Likely bond responsible

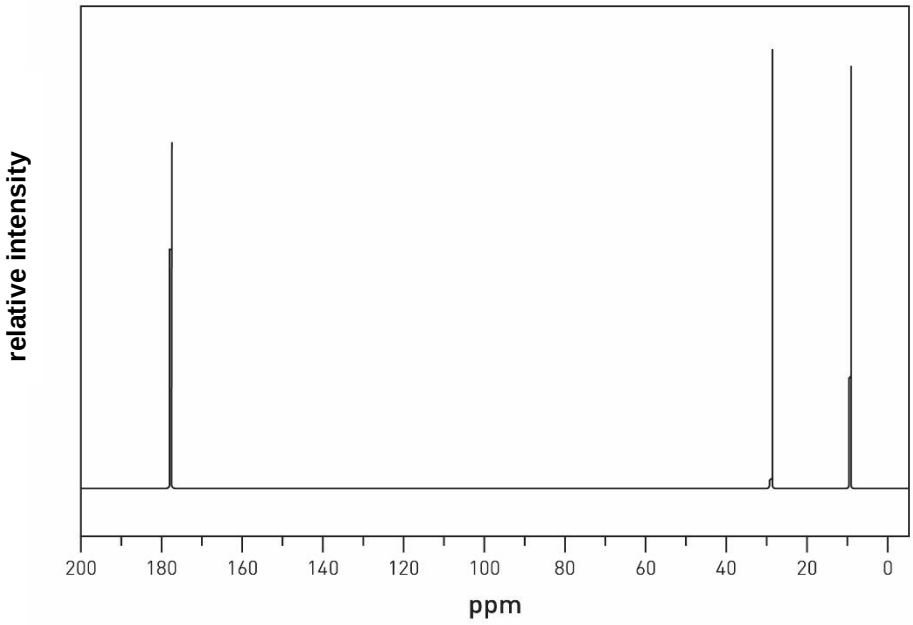
c. **i.** Draw a possible structure for this molecule.

1 mark

ii. Explain how the ^{13}C NMR spectrum below supports the structure you have drawn.

Note: The carbon environment R–CH_2CO– is not listed in your data book; it has a shift of 25 to 55 ppm.

3 marks



Data: SDBS Web, http://sdbs.db.aist.go.jp,
National Institute of Advanced Industrial Science and Technology

Question 4 (8 marks)

Ethanamine is used widely to add amine groups to larger organic molecules. It is a gas at room temperature but forms alkaline solutions in water.

Ethanamine is bubbled through 500 mL of water to form a solution. The concentration of the solution is determined through a titration with 0.12 M HCl. 20.00 mL aliquots from the ethanamine solution are added to flasks, and phenolphthalein indicator is added. The titres of HCl obtained are shown below.

Titres: 15.80 mL 15.26 mL 15.45 mL 15.76 mL

a. **i.** Ethanamine could be synthesised from ethane.

Outline the steps involved in this synthesis and include any required reagents and catalysts.

2 marks

_____

_____

_____

_____

ii. Write a balanced equation for the reaction between ethanamine and HCl.

1 mark

_____

b. The values of the titres obtained fluctuate more than is generally acceptable for a titration. One reason for this variation is a flaw in the procedure used.

Identify what this flaw is and how it affects the titres obtained.

2 marks

_____

_____

_____

_____

c. Average the titres obtained and use the mean titre to calculate the concentration of the ethanamine solution.

3 marks

_____

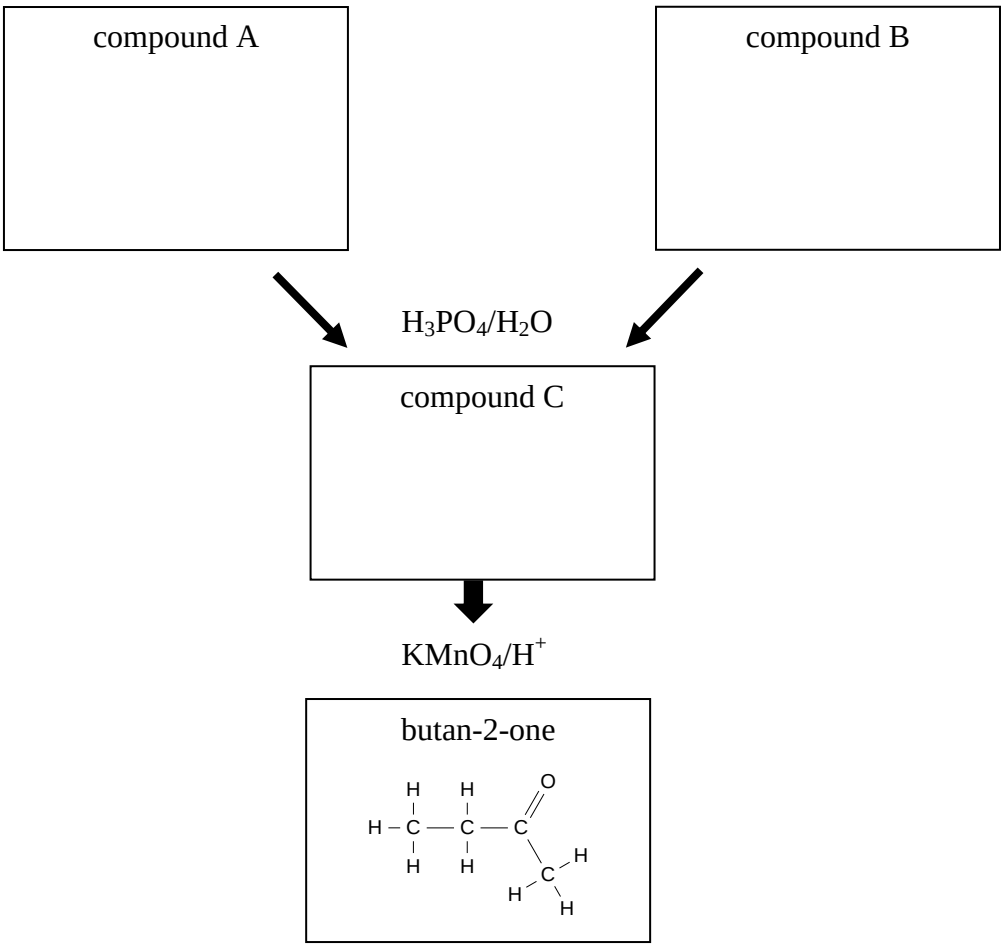
_____

_____

_____

Question 5 (6 marks)

Butan-2-one is also known as methyl ethyl ketone. It is used in paints, coatings and polyesters. It is a good solvent of polar molecules and it evaporates quickly when used as a glue. A flowchart is outlined below for the manufacture of butan-2-one. Butan-2-one can be made from compound A or from compound B. Both compounds are alkenes.



a. Use the boxes provided to draw compounds A and B.

2 marks

b. **i.** Use the box provided to draw compound C.

1 mark

ii. Give the systematic name for compound C.

1 mark

_____

c. Write a balanced half-equation for the reduction of MnO_4^- to Mn^{2+} in acid conditions.

1 mark

_____

d. Rank the following compounds in order of boiling point (lowest to highest).

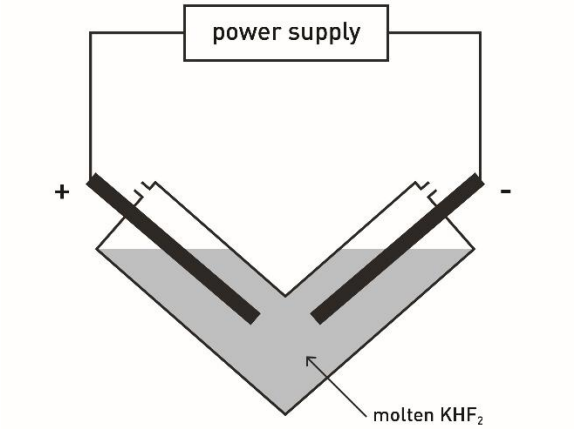
butan-2-ol pentane butan-2-one

1 mark

_____

Question 6 (9 marks)

Fluorine gas is usually produced by electrolysis. One commercial process, sketched below, uses molten potassium hydrogen fluoride (KHF_2) as a source of fluoride ions. Carbon electrodes are inserted into the V-shaped tube and a current is then passed through the liquid. Gases are formed at each electrode.



a. Use the spaces provided to write the half-equations and overall equation for the electrolysis of molten KHF_2.

3 marks

Anode _____

Cathode _____

Overall equation _____

b. Suggest a reason for the use of a V-shaped tube in this process.

1 mark

_____

c. It would be much cheaper to run electrolysis on an aqueous solution of potassium fluoride, KF.

Use the spaces below to write half-equations for the electrolysis of aqueous KF.

2 marks

Anode _____

Cathode _____

d. Given that the temperature is 840 °C and the pressure 185 kPa, what volume of gas is produced at the anode of the KHF_2 cell when a current of 50.8 amperes runs for 12.0 hours?

3 marks

_____

_____

_____

_____

Question 7 (8 marks)

The commercial production of nitric acid, HNO_3, involves the two reversible reactions below.

$N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$ $\Delta H = -92.3$ kJ mol^{-1} Reaction 1

$4NH_3(g) + 5O_2(g) \rightleftharpoons 4NO(g) + 6H_2O(g)$ $\Delta H = -907$ kJ mol^{-1} Reaction 2

a. What is the oxidation number of nitrogen in each of the following compounds ?

2 marks

Compound	NH_3	HNO_3
Oxidation number		

b. The pressure of the equilibrium mixtures of each reaction is increased.

Use the spaces in the table below to explain the effect on the ammonia concentration in each reaction.

4 marks

Reaction	**Effect of pressure increase**
1	
2	

c. The temperature of an equilibrium mixture of reaction 1 is increased.

Explain the effect on the yield and the rate of the forward reaction.

2 marks

	Effect of temperature increase
Rate of reaction	
Yield of ammonia	

Question 8 (10 marks)

a. Write balanced equations for each of the following.

i. The fermentation of glucose.

1 mark

_____

ii. The hydrolysis of sucrose.

1 mark

_____

iii. The reaction between stearic acid and ethanol. States are not required.

1 mark

_____

b. Bromine solution will react with some fatty acids. In an experiment, a 0.26 mol sample of fatty acid is found to react with 166 g of bromine.

Suggest an identity for the fatty acid that is consistent with the data given.

2 marks

_____

_____

_____

c. An athlete drinks 200 mL of a sucrose solution after an event. The energy obtained by the athlete is 46 kJ.
What is the concentration of the sucrose solution, in g L^{-1}?

2 marks

_____

_____

_____

d. **i.** Draw **one** of the possible dipeptides formed when serine reacts with cysteine. Use a structural diagram.

1 mark

ii. The shape of a protein is dependent on its tertiary structure.

Annotate your diagram from **part d.i.** to explain the likely forms of tertiary structure that will result from the presence of serine and cysteine in a protein chain.

2 marks

Question 9 (10 marks)

Lactose is a disaccharide. It is a sugar formed from glucose and galactose. There are two forms of lactose, α-lactose and β-lactose. These two molecules are stereoisomers.

a. **i.** Name the bond that joins the glucose and galactose molecules in lactose.

1 mark

_____

ii. Will lactose be soluble in water?

1 mark

_____

_____

iii. Lactose has about one-third the sweetness of sucrose.

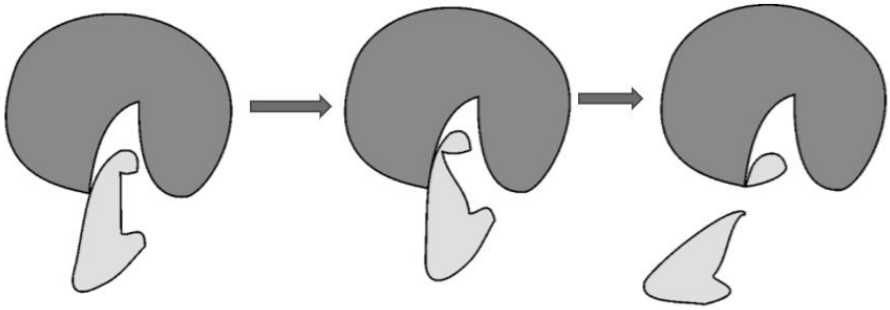
Explain why aspartame is found in low-kilojoule diets instead of lactose.

2 marks

_____

_____

b. The enzyme lactase can be used to hydrolyse lactose. The diagram below illustrates the mechanism of the action of a catalyst.



i. What is the name for this model of the way a catalyst works?

1 mark

_____

ii. Why is lactase NOT likely to be effective on both α-lactose and β-lactose?

1 mark

_____

_____

iii. A sample of lactase is heated to 80 °C and then cooled.

What is the effect that heating has on the action of the catalyst?

1 mark

_____

_____

c. A proportion of humans have significant difficulty digesting lactose. This condition is referred to as lactose intolerance.

i. Give a concise explanation of lactose intolerance.

2 marks

_____

_____

ii. List **one** way in which lactose intolerance can be addressed.

1 mark

_____

Question 10 (11 marks)

A student purchases an alcohol burner like the one shown in the image on the right in order to run an investigation into the heats of combustion of a series of alcohols. The student's hypothesis, procedure and results are listed below.

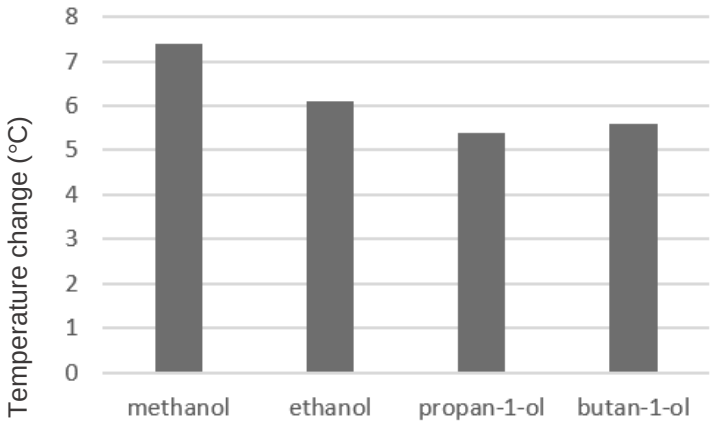
Hypothesis: The molar heat of combustion of an alcohol will increase with the molar mass of the alcohol.

Method

1. Add a sample of methanol to the burner.
2. Sit the burner under a beaker containing 500 mL of water.
3. Record the temperature of the water.
4. Light the burner and let it burn for 2 minutes.
5. Record the temperature change.
6. Empty the methanol, clean and add ethanol.
7. Repeat the procedure for ethanol.
8. Repeat the procedure for propan-1-ol and butan-1-ol.

Results

Alcohol	Initial water temperature (°C)	Final water temperature (°C)
methanol	14.0	21.4
ethanol	20.8	26.9
propan-1-ol	25.5	30.9
butan-1-ol	30.2	35.8



Conclusion: The hypothesis has not been validated. The energy density did not increase with molar mass.

a. For this experiment, identify the following.

3 marks

Independent variable _____

Dependent variable _____

Controlled variable _____

b. The student chose to use ΔT on the vertical axis instead of energy released.

Explain the implications of this decision.

2 marks

_____

_____

c. The student chose to light the ethanol in the burner without allowing the contents of the beaker to return to room temperature.

Explain the implications of this decision.

2 marks

_____

_____

d. Explain the student's conclusion.

2 marks

_____

_____

e. Suggest **two** improvements to the design of the experiment to better test the stated hypothesis.

2 marks

Improvement 1 _____

_____

Improvement 2 _____

_____

END OF QUESTION AND ANSWER BOOK