Year 12 Unit 3 Revision

April 2024

Writing time: 112 minutes

Student's Name: _____

Teacher: _____

Structure of booklet

Section	Number of Questions	Marks
Short response questions	6	112
	Total	**112**

Directions to students

Instructions
- Students will have 10 minutes reading time and 112 minutes to write.
- All short answer questions must be answered in the space provided.

Materials
- Students **are permitted** to pens/pencils, highlighters, erasers, sharpeners, rulers, and an approved scientific calculator.
- Students are **NOT permitted** to use white out liquid/tape, phones or electronic devices, including smart watches.
- Students may use the VCAA data booklet provided for them earlier in the year.

Data booklet 2024

The task
- Please ensure that you write all responses in the space provide in the question booklet and show all working out
- There are a total of **112** marks available.

1. Consider the electrolytic cell shown figure 1.
For this cell answer the following questions.

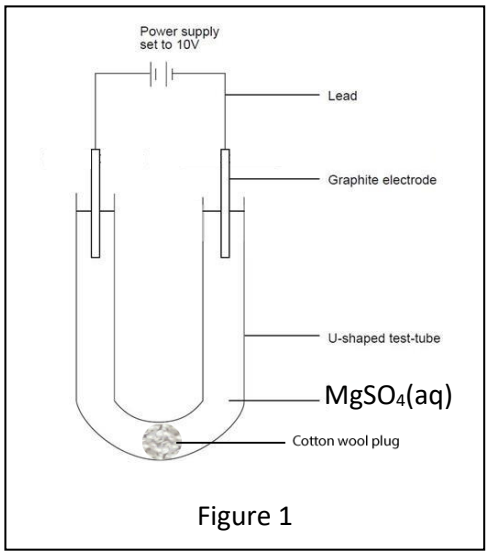

Figure 1

a. Write the balanced equation, with states, for the half reaction taking place at the:
Anode _____2 marks
Cathode _____ 2 marks

b. Explain how the pH at the anode will change over time as the cell operates. 2 marks

_____

_____

c. A current of 5.50 amps was applied for 1.50 minutes. Calculate the volume, in litres, of gas produced at the cathode at SLC? 4 marks

2. Consider the electrochemical cell shown on the right. It is composed of a 1.0 M $ZnSO_4$ electrolyte solution and two carbon electrodes connected to a power source.

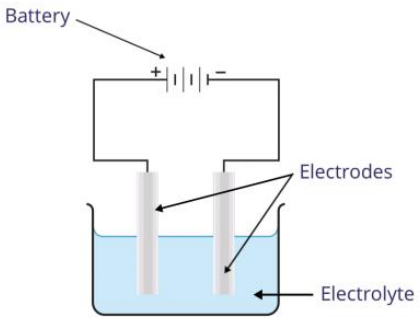

Figure 2

a. Give the half reactions taking place at the:
i. Anode _____ 2 marks

ii. Cathode _____2 marks

b. Which electrode is gaining mass? 1 mark

_____

c. The power source delivers a current at a voltage of 5.00 volts. If electrical energy equivalent to 4000 kJ is delivered what is the mass gain of the electrode specified in b. above? 4 marks

3. Consider a molten carbonate fuel cell with molten Na_2CO_3 electrolyte operating at 800°C.

a. In the space provided below, draw a molten carbonate (Na_2CO_3) fuel cell burning methane gas in atmospheric oxygen. 4 marks

- label the anode and cathode.
- identify the ions moving through the electrolyte and clearly indicate their direction
- give the half equations, states not necessary, for the reactions taking place at the:

Anode _____

Cathode _____

b. Give the balanced equation, states included, for the overall reaction taking place in the fuel cell. 2 marks

c. A great deal of heat is produced during the operation of the fuel. Give one use for the hot waste gases, that would maximise electrical energy output. 2 marks

_____

_____

_____

_____

_____

d. The exhaust gases are finally vented out of the fuel cell into the atmosphere at SLC. Calculate the net volume, in litres, of CO_2 gas added to the atmosphere over a 24.00 hour period if the cell produces a constant current of 5.90 amps. Give your answer to the right number of significant figures. 5 marks

4. The predominant constituent of Jatropha curcas oil is a fatty acid called oleic acid. The composition of the plant oil is given in table 1 below.

Oil	% composition by mass	Heat of combustion (kJ/g)
Oleic acid	50	39.4
Linoleic acid	40	37.1
Palmitic acid	10	39.0

Table 1

Figure 3
Jatropha curcas

Jatropha curcas is known for its ability to grow in low-quality or marginal soils, which makes it suitable for cultivation in areas where other crops may struggle. It is often referred to as a "wasteland plant" because it can thrive in soils that are nutrient-poor, sandy, rocky, or otherwise unsuitable for many other agricultural crops.

a. Calculate the amount of energy given by 0.1000 kg of pure Jatropha curcas oil. 2 marks

b. Petrodiesel, produced from crude oil is mainly characterised as $C_{12}H_{24}$. Compare biodiesel produced from Jatopha curcas oil with petrodiesel by completing the table below. Use your knowledge of chemistry to give a detailed explanation.

Factor	Biodiesel	Petrodiesel
Energy density (kJ/g)		3 marks
Usage in low temperature climates		3 marks

c. Compare and contrast the two biofuels, namely bioethanol and biodiesel by answering the questions in the table below.

Question	Answer	Justification
Is bioethanol sustainable?	1 mark	_____ _____ _____ _____ _____2 marks
Is biodiesel made from Jatopha curcas oil sustainable?	1 mark	_____ _____ _____ _____ _____2 marks

d. Given that the average molecule in petrodiesel has the molecular formula $C_{12}H_{24}$:

i. give the balanced equation, states included, for the complete combustion of petrodiesel at SLC.

_____2 marks

ii. calculate the volume, in litres, of gas released from the complete combustion that occurs when 480.00 litres of oxygen completely react in excess fuel, at SLC. Give your answer to the right number of significant figures. 2 marks

e. The simplified reaction pathway shown below in fig. 4 is of the transesterification process to form biodiesel.

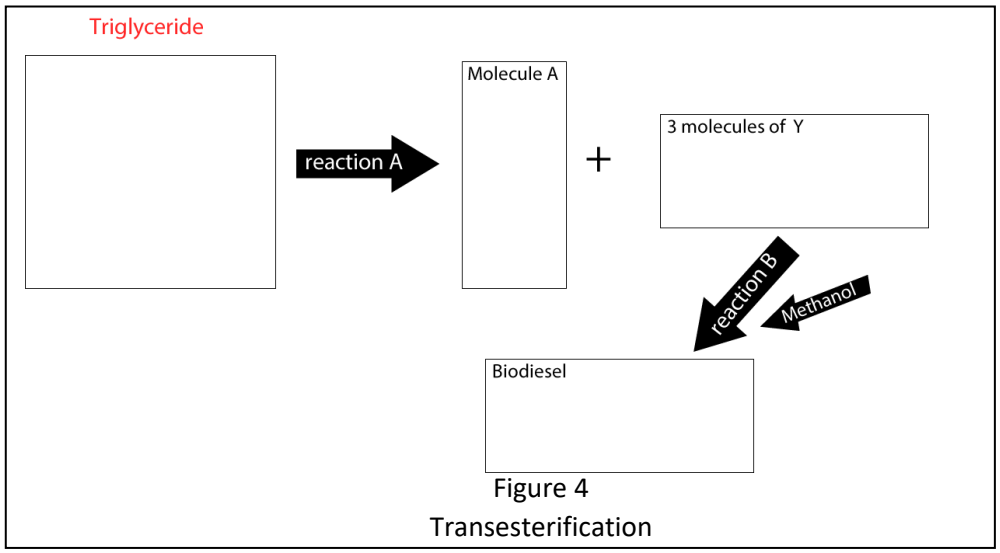

Figure 4
Transesterification

i. Draw the structural formula, in the box provided in fig 4, of one triglyceride molecule formed from oleic acid. Use the molecular formula of oleic acid ($C_{17}H_{33}$-COOH) in your representation of the triglyceride. 2 marks

ii. What class of reaction is represented by reaction "A"?

_____ 1 mark

iii. Apart from the triglyceride, what other molecule is needed as a reactant for reaction "A"? _____ 1 mark

iv. Draw the structural formula of molecule "A" in the box provided and give its IUPAC name. 2 marks

v. To which homologous group do the molecules of "Y" belong to?
_____ 1 mark

vi. To what general class of reaction does reaction "B" belong to?
_____ 1 mark

vii. Give the ***condensed*** formula for the biodiesel formed as a product of reaction "B" in the box provided in fig 4, circle and name the functional group within the biodiesel molecule. 3 marks

viii. With reference to functional groups and intermolecular bonds discuss why molecule "Y" is not used directly as a fuel but rather is converted into biodiesel by reaction with methanol. 3 marks

f. In an attempt to calculate the heat of combustion, in kJ/g, the setup shown in fig.5 was used. The entry, shown below, was found in a student's log book.

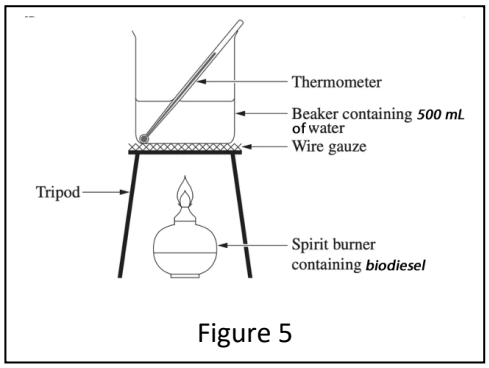

Figure 5

"Mass of spirit burner and fuel before combustion ---------- 234.00 grams
Mass of spirit burner and fuel after combustion ---------- 231.69 grams
Temperature of water before combustion ------- 25.0 ^{o}C
Temperature of water after combustion ------- 69.2 ^{o}C

i. Calculate the amount of energy, in kJ, released by the burning of the fuel. Give your answer to the right number of significant figures. 3 marks

ii. What is assumed when calculating the answer to question i. above? 1 mark

iii. Calculate the energy density of the fuel in kJ/g. 1 mark

iv. The published literature value for the energy density of the fuel is 34.2 kJ/g. Discuss how this compares with the student's experimental result and suggest two possible errors that may have contributed to the discrepancy. 3 marks

5. Consider the galvanic cell shown on the right in fig. 6. It is allowed to discharge at standard conditions.

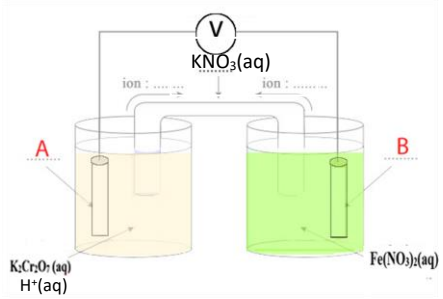

Figure 6

a. What is the theoretical voltage registered by the voltmeter. 1 mark

b. Give a possible material that can be used to form both electrodes "A" and "B" 1 mark

_____

c. Describe how the function of the cell in fig 6 would change if electrode "A" is replaced with an iron electrode. Justify your answer with reference to the electrochemical series given in the data booklet. 2 marks

_____

_____

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_____

d. State one limitation of the electrochemical series provided in your data book. 1 mark

_____

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_____

e. Describe the colour change that takes place in the half cell with electrode "A", during discharge. 1 mark

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f. In the space provided in fig. 6 indicate the ion and its state, travelling through the salt bridge in the direction indicated by the arrows. 2 marks

g. Describe how the pH in the half cell with electrode "A" changes over time during discharge and give an explanation using a balanced half equation. 2 marks

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h. The cell is now connected to a power source in order to recharge, as shown in fig 7.

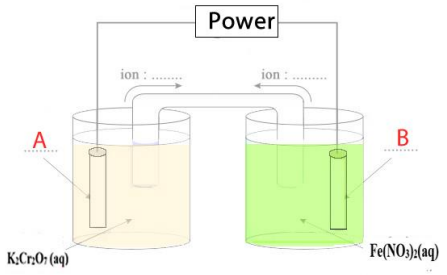

Figure 7

i. Complete the table below 8 marks

	Recharge	Discharge
Polarity of electrode "A"		
Polarity of electrode "B"		
Oxidation takes place at which electrode		
Reduction takes place at which electrode		
Energy transformation		
Voltage produced		
Voltage applied		
Reaction taking place at electrode "B"		

ii. With reference to the electrochemical series, give an explanation as to why recharging this particular galvanic cell might be very difficult. 2 marks

_____

_____

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_____

6. Calcium carbonate (limestone) powder was added to a 250 mL beaker and then reacted with 100 mL of a 0.1 M HCl. Carbon dioxide gas and liquid water were two of the three products formed from this reaction.

   a. Using your knowledge of acid reactions covered previously (year 11), write the balanced chemical equation for the reaction taking place at SLC. States included 2 marks

_____

   b. The volume of gas produced over time was graphed and shown in fig 8. The graph shows the reaction taking place at 10 °C without a catalyst.

      i. Draw a clearly labelled graph of volume of gas versus time for exactly the same reaction with the same amount of reactants but at 30 °C on the set of axes shown in fig 8. 1 mark

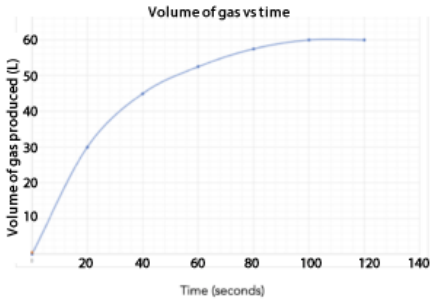

Figure 8

      ii. On the same set of axes, shown in fig. 8, draw a clearly labelled graph of volume of gas versus time for the same reaction but with 200 mL of 0.05 M HCl solution. Justify the shape of the curve using collision theory. 3 marks

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_____

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_____

_____

   c. Shown on the right is the Maxwell-Boltzmann distribution curve for particles at 10 °C.

      i. Draw the distribution curve for the same amount of particles at 30 °C. 2 marks

      ii. Use this distribution curve to justify the shape of the curve drawn as an answer to question b part i. above. 2 marks

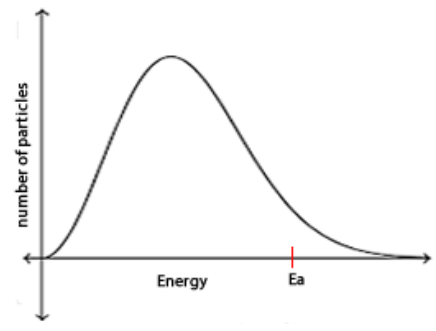

Figure 9

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d. Use the maxwell-Boltzmann distribution curve shown in fig 10 to explain why a catalyst increases the rate of a reaction. 4 marks

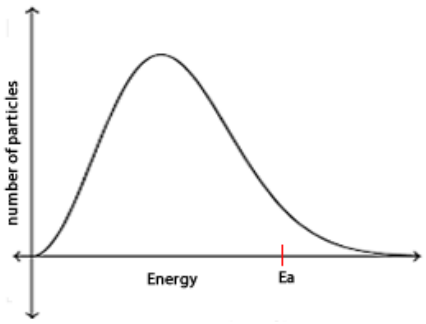

Figure 10

e. For each of the following statements below state if they are true or false and give a brief explanation as to why.

i. If a catalyst is used the reaction above, the rate will increase due to the number of collisions between the reactants increase 2 marks

ii. As the temperature of the acid solution in the reaction above is increased so does the rate of the reaction because all reactant particles have greater kinetic energy and collide more frequently. 2 marks

iii. Consider the reaction to form ammonia via the reaction below.

$$3H_2(g) + N_2(g) \rightarrow 2NH_3(g) \quad \Delta H < 0$$

A catalyst increases the reaction rate by decreasing the activation energy of the forward and backward reactions by the same proportion. 2 marks

End of assessment