



Units 3 and 4 Chemistry

Practice Exam Question and Answer Booklet

Duration: 15 minutes reading time, 2 hours and 30 minutes writing time

Structure of book:

Section	Number of questions	Number of questions to be answered	Number of marks
A	30	30	30
B	9	9	90
Total			120

- Students are permitted to bring into the examination room: pens, pencils, highlighters, erasers and rulers.
- Students are not permitted to bring into the examination room: blank sheets of paper and/or white out liquid/tape.
- One scientific calculator is allowed in this examination.

Materials supplied:

- This question and answer booklet of 25 pages.

Instructions:

- You must complete all questions of the examination.
- Write all your answers in the spaces provided in this booklet.

Section A – Multiple-choice questions

Instructions

Answer all questions by circling your choice.

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

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

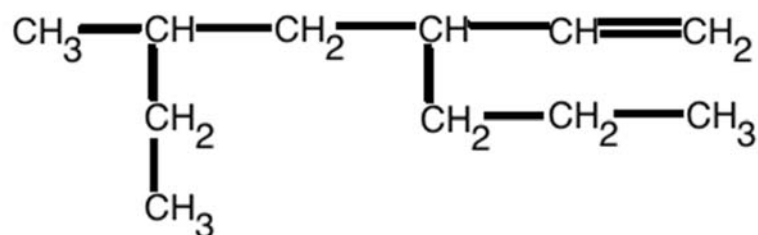
Marks will not be deducted for incorrect answers.

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

Questions

Question 1

What is the correct IUPAC name of the following compound?



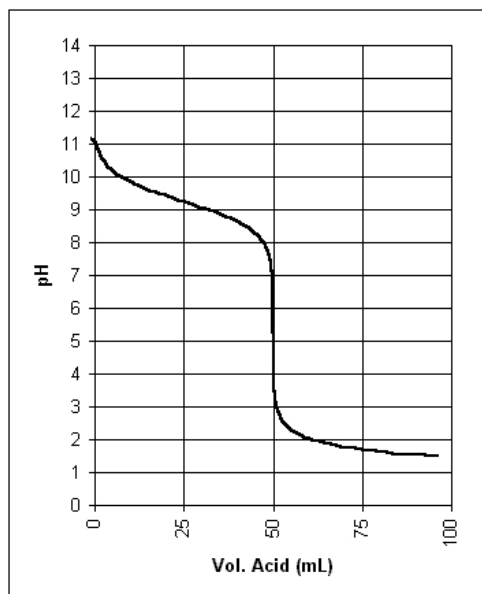
- A. 3-propyl-5-methylhept-1-ene
- B. 3-methyl-5-ethyloctene
- C. 2-ethyl-4-propylhex-5-ene
- D. 5-methyl-3-propylhept-1-ene

Question 2

In which species does sulfur have the same oxidation state as it has in H₂S₂O₃?

- A. SO₂
- B. H₂S₄O₆
- C. SCl₂
- D. S₂F₁₀

Use the following titration curve for questions 3 and 4



Question 3

The titration curve represents a titration of:

- A. a strong acid and a strong base
- B. a strong acid and a weak base
- C. a weak acid and a strong base
- D. a weak acid and a weak base

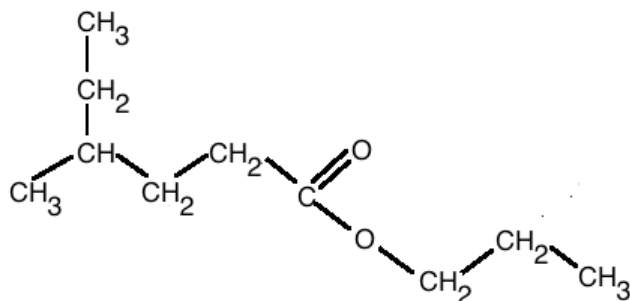
Question 4

Which indicator would be the least appropriate for the detection of the end point?

- A. Thymol blue
- B. Methyl red
- C. Bromothymol blue
- D. Bromophenol blue

Question 5

Which two reactants would be required to produce the following molecule in the presence of sulfuric acid catalyst?



- A. propan-3-ol and 2-ethylpentanoic acid
- B. propane and 5-ethylpentanoic acid
- C. propan-1-ol and 4-methylhexanoic acid
- D. propane and 3-methylhexanoic acid

Question 6

Which of the following is not a reactant or catalyst for the synthesis of biodiesel?

- A. Sodium hydroxide
- B. Glycerol
- C. Methanol or ethanol
- D. Triglycerides

Question 7

In which solution would the concentration of hydronium ions be highest?

- A. 0.1 M HCl
- B. 0.1 M NaOH
- C. 1.0 M HNO₂
- D. 1.0 M HF

Question 8

A 10 mL aliquot of 1.0 M NaOH is transferred to a conical flask, which is then titrated with HCl of unknown concentration from a burette. Which of the following, if done before the commencement of the titration, would result in the calculated concentration of HCl being **higher** than the actual concentration?

- A. Rinsing the burette with deionised water
- B. Rinsing the pipette with deionised water
- C. Rinsing the conical flask with 1.0 M NaOH
- D. Rinsing the pipette with 1.0 M NaOH

Question 9

Which technique would be most appropriate for determining the relative amounts of the isotopes ²⁴Mg, ²⁵Mg and ²⁶Mg in a sample of magnesium metal?

- A. UV-visible spectroscopy
- B. Atomic absorption spectroscopy
- C. Mass spectrometry
- D. Gas chromatography

Question 10

2.44 g of an unidentified gas is contained in a 1.982 L vessel with a pressure of 1.00 atm at 24.0 °C. What is the molecular formula of the gas?

- A. CO₂
- B. CO
- C. C₂H₄
- D. NO

Question 11

Which of the following types of bonds or forces of attraction are not implicated in the tertiary structure of proteins?

- A. Hydrogen bonds
- B. Peptide linkages
- C. Disulfide links
- D. Dispersion forces

Question 12

Which of the following represents the balanced chemical equation for anaerobic cellular respiration in yeast cells?

- A. $\text{C}_6\text{H}_{12}\text{O}_6 + 6\text{O}_2 \rightarrow 6\text{CO}_2 + 6\text{H}_2\text{O}$
- B. $\text{C}_6\text{H}_{12}\text{O}_6 \rightarrow 2\text{C}_2\text{H}_5\text{OH} + 2\text{CO}_2$
- C. $\text{C}_6\text{H}_{12}\text{O}_6 \rightarrow 2\text{C}_3\text{H}_6\text{O}_3$
- D. $6\text{CO}_2 + 6\text{H}_2\text{O} \rightarrow \text{C}_6\text{H}_{12}\text{O}_6 + 6\text{O}_2$

Question 13

Which fatty acid has highest degree of unsaturation?

- A. Lauric acid
- B. Palmitoleic acid
- C. Arachidonic acid
- D. Arachidic acid

Question 14

How many peaks would be formed in the ^1H NMR and ^{13}C NMR spectra (both low resolution) of dimethylpropan-1-ol, respectively?

- A. 2 and 3
- B. 3 and 3
- C. 4 and 3
- D. 4 and 4

Question 15

Which reaction forms butanoic acid from butan-1-ol?

- A. Substitution
- B. Addition
- C. Oxidation
- D. Reduction

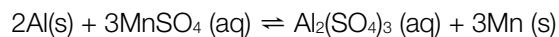
Question 16

Which of the following is the **best** explanation as to why increasing temperature increases the rate of chemical reactions?

- A. Increased heat weakens bonds in reactants so that they can form products faster
- B. Increased heat increases the frequency of collisions, as particles move faster
- C. Increased heat drives the forward reaction of equilibria and hence increases yield
- D. Increased heat means that a greater proportion of particles have energy greater than the activation energy for the reaction

Question 17

What is the expression for the equilibrium constant for the following reaction?



- A. $k = \frac{[\text{Al}_2(\text{SO}_4)_3]}{[\text{MnSO}_4]^3}$
- B. $k = \frac{[\text{Al}_2(\text{SO}_4)_3][\text{Mn}]^3}{[\text{Al}]^2[\text{MnSO}_4]^3}$
- C. $k = \frac{[\text{Al}_2(\text{SO}_4)]}{[\text{MnSO}_4]}$
- D. $k = \frac{[\text{Mn}]^3}{[\text{Al}]^2}$

Question 18

Which of the following would not increase the product **yield** of the following reaction?

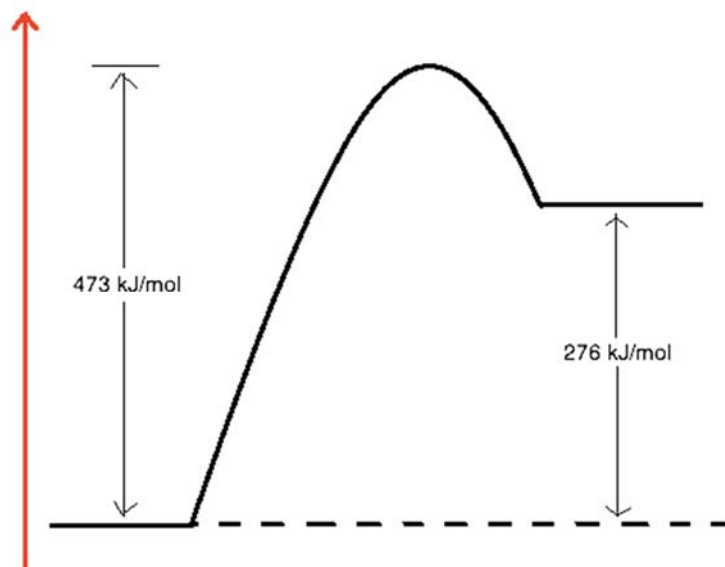
- A. Removal of carbon dioxide from reaction vessel
- B. Increase in temperature
- C. Addition of methane into reaction vessel
- D. Increase in pressure

Question 19

What effect does the presence of a catalyst have on reaction **rates** in an equilibrium system?

- A. Increases the rate of the forward reaction
- B. Increases the rate of the reverse reaction
- C. Increases the rate of both reactions
- D. Does not impact on the rate of either reaction

Use the following energy profile diagram for questions 20 and 21



Question 20

What is the value of ΔH for the forward reaction (in kJ/mol)?

- A. -197
- B. +197
- C. +276
- D. +473

Question 21

What is the activation energy of the reverse reaction (in kJ/mol)?

- A. 473
- B. 196
- C. 276
- D. 749

Question 22

A solution has a pH of 7.8 at 25°C. What is the concentration of hydroxide ions?

- A. 1.6×10^{-8} M
- B. 0.89 M
- C. 6.3×10^{-7} M
- D. 1.0×10^{-7} M

The following information is to be used for questions 23 and 24

A 3.200 A current was passed through a heating implement in a bomb calorimeter at a potential difference of 7.450 V for 23.40 s. The temperature changed from 22.50°C to 22.95°C. The same calorimeter was then used to measure the heat released for the complete combustion of 0.00350 mol of reactant X. The temperature increased by 0.780 °C.

Question 23

What was the calibration factor of the calorimeter, in J °C⁻¹?

- A. 1240
- B. 715.2
- C. 557.9
- D. 0.4585

Question 24

What is ΔH for the reaction in which one mole of X is combusted in excess oxygen, in kJ/mol?

- A. +0.967
- B. -354.2
- C. +3.38
- D. -276

The following information is to be used for questions 25, 26 and 27

A galvanic cell is constructed from a Cu²⁺/Cu half-cell and a Al³⁺/Al half-cell at 35°C.

Question 25

Which is the equation that correctly represents the spontaneous chemical reaction that will occur?

- A. $2\text{Al}^{3+}(\text{aq}) + 3\text{Cu}^{2+}(\text{aq}) \rightarrow 2\text{Al}(\text{s}) + 3\text{Cu}(\text{s})$
- B. $\text{Cu}^{2+}(\text{aq}) + 2\text{Al}(\text{s}) \rightarrow \text{Al}^{3+}(\text{aq}) + \text{Cu}(\text{s})$
- C. $2\text{Al}^{3+}(\text{aq}) + 3\text{Cu}(\text{s}) \rightarrow 2\text{Al}(\text{s}) + 3\text{Cu}^{2+}(\text{aq})$
- D. $2\text{Al}(\text{s}) + 3\text{Cu}^{2+}(\text{aq}) \rightarrow 2\text{Al}^{3+}(\text{aq}) + 3\text{Cu}(\text{s})$

Question 26

What is the potential difference of the galvanic cell?

- A. -2.01 V
- B. +2.01 V
- C. -1.33 V
- D. Cannot be determined from the electrochemical series

Question 27

What forms the internal circuit of this galvanic cell?

- A. Electrons flowing through the wire connecting the metal electrodes
- B. Ions flowing through the salt bridge
- C. Electrons being donated by the Cu atoms in the solid anode
- D. Electrons being accepted by Al³⁺ ions in solution at the cathode

Question 28

Industrial production of which metal requires the use of a molten, rather than an aqueous electrolyte?

- A. Calcium
- B. Iron
- C. Lead
- D. Nickel

Question 29

Which of the following is a renewable energy resource?

- A. Crude oil
- B. Uranium
- C. Methane
- D. Coal

Question 30

85.05 g of a particular metal was produced by electrolysis when a current of 135.1 A was applied for 83 minutes and 20 seconds. If the charge of metal cation is $2+$, what is the identity of the metal formed?

- A. Be
- B. Mg
- C. Ca
- D. Sr

Section B – Short-answer questions

Instructions

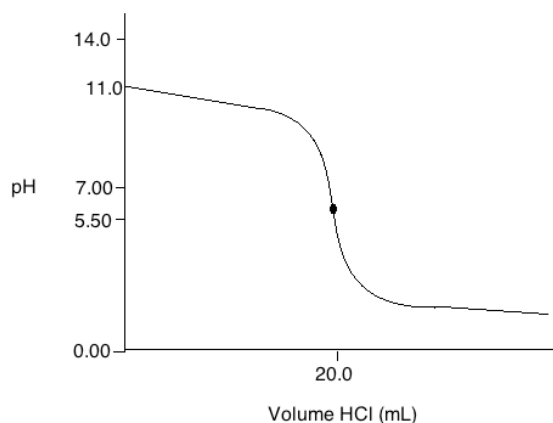
Answer all questions in the spaces provided.

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

Questions

Question 1

45.0 mL of a base, XOH, of unknown concentration in a conical flask was titrated with 1.00 M HCl.



- a. Was XOH a weak base or a strong base? Explain two features from the titration curve as evidence to support your answer.

3 marks

- b. Explain the difference between 'equivalence point' and 'end point' in a titration.

2 marks

- c. Which indicator would be the most appropriate for this titration?

1 mark

- d. Calculate the concentration of the base, XOH.

3 marks

- e. If the burette was rinsed with deionised water instead of HCl before titration, how would this affect the calculated concentration of the base? Explain your answer.

3 marks

Total: 12 marks

Question 2

- a. Draw the two possible dipeptides that can be formed from glycine and serine, showing all bonds.

2 marks

- b. On one of the two dipeptides, circle and label the linkage group that joins them together. On the other, individually circle and label the two functional groups that occur at either end of the dipeptide.

2 marks

- c. What is the name of the reaction that leads to the formation of the linkage groups indicated above? Also indicate what the by-product of this reaction is.

1 mark

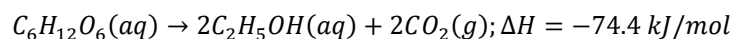
- d. With regard to the terminal functional groups as indicated in question 2(b), briefly explain how each of them interacts with water in a neutral pH environment.

2 marks

Total: 7 marks

Question 3

Consider the following reaction:



- a. State Le Chatelier's Principle.

1 mark

- b. With reference to Le Chatelier's Principle, explain the effect of each of the following on the overall yield of ethanol:

- i. increasing the temperature of the reaction vessel

2 marks

- ii. increasing the volume of the reaction vessel

2 marks

- iii. addition of argon gas into the reaction vessel

1 mark

- c. Ethanol produced by this process can be used as an alternative fuel source to provide energy.
- i. Give two advantages of using ethanol as an energy source.

2 marks

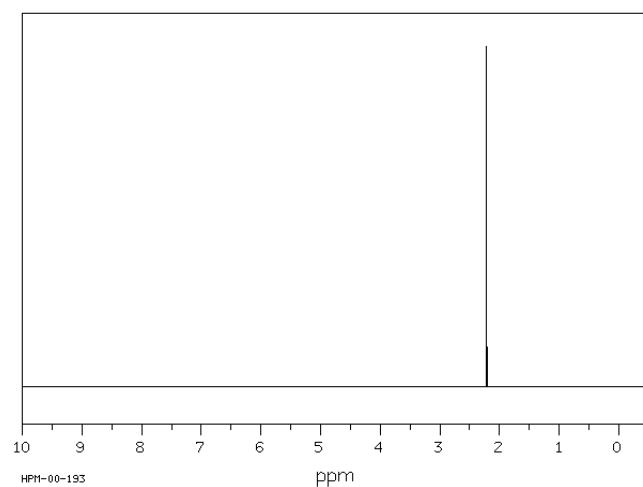
- ii. Give one disadvantage of using ethanol as an energy source.

1 marks

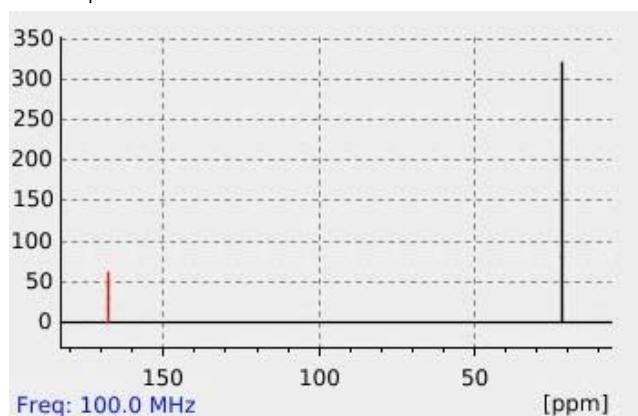
Total: 9 marks

Question 4

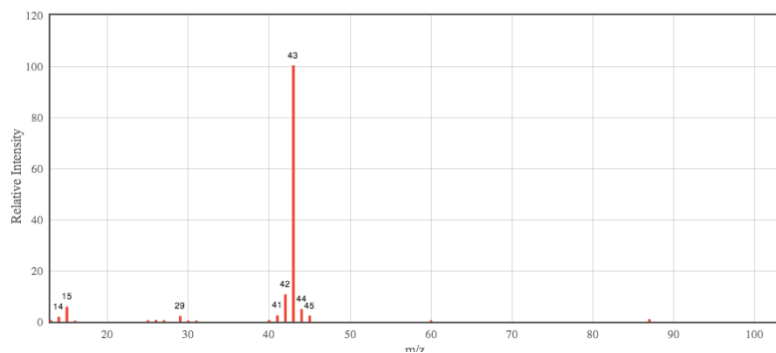
Refer to the following four spectra (hint: the molecule contains only C, H and O)

 ^1H NMR Spectrum

(http://www.chemicalbook.com/SpectrumEN_108-24-7_1HNMR.htm)

 ^{13}C NMR Spectrum

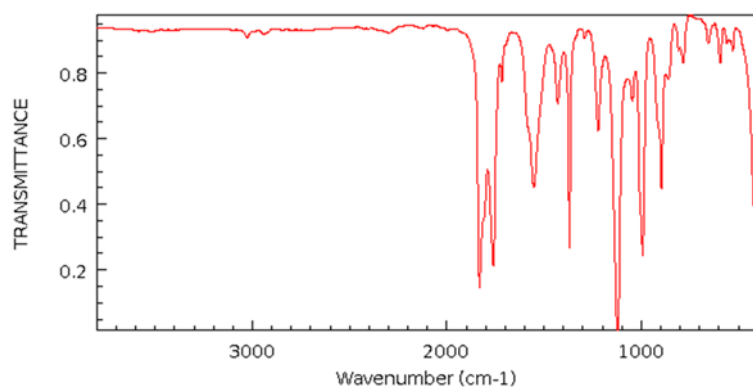
(http://nmrshiftdb.nmr.uni-koeln.de/portal/js_pane/P-Results/nmrshiftdbaction/showDetailsFromHome/molNumber/10016742)

Mass Spectrum*

(<http://webbook.nist.gov/cgi/cbook.cgi?ID=C108247&Mask=200>)

*There is a small peak at $m/z=102$

Infrared Spectrum



NIST Chemistry WebBook (<http://webbook.nist.gov/chemistry>)

(<http://webbook.nist.gov/cgi/cbook.cgi?ID=C108247&Type=IR-SPEC&Index=2>)

- a. Briefly explain any specific information of significance about the molecule provided by the:
- i. ^1H NMR spectrum

2 marks

- ii. ^{13}C NMR spectrum

2 marks

- iii. mass spectrum

2 marks

iv. infrared spectrum

2 marks

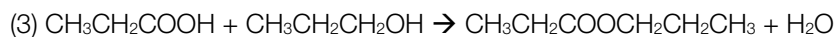
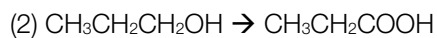
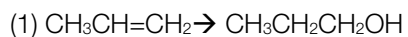
- b. In light of all of this information, suggest a possible structure of the molecule represented by the four spectra, showing all atoms and bonds.

2 marks

Total: 10 marks

Question 5

Consider the following organic pathway:



a. Name the reaction that occurs:

i. in step (1)

_____ 1 mark

ii. in step (2)

_____ 1 mark

iii. in step (3)

_____ 1 mark

b. Suggest any additional reagents and/or catalysts required:

i. for step (1)

_____ 2 marks

ii. for step (2)

_____ 1 mark

iii. for step (3)

_____ 1 mark

c. Provide the systematic IUPAC name for the organic product in step (3).

_____ 1 mark

- d. An infrared spectrum is produced from the reaction mixture in step (3). Assume that it was possible to remove all water from the mixture, and that this was done.
- i. Generally, explain how infrared radiation interacts with molecules, and outline what information infrared spectra give about a molecule.

2 marks

- ii. Provide one piece of information from an infrared spectrum of the step (3) reaction mixture could help to determine whether or not all reactants from had been converted to the product (assuming neither is in excess).

2 marks

Total: 12 marks

Question 6

An electrolytic cell was set up to extract sodium metal from molten sodium chloride. The cell had a potential difference of 6.40 V. Over the course of 24 hours, electricity was passed through the cell, with the total energy input being 518.4 kJ.

- a. Calculate the mass of sodium metal extracted during this time.

6 marks

- b. Suggest why a molten electrolyte had to be used, even though an aqueous electrolyte would incur a lower cost and energy expenditure.

2 marks

The chemist who was managing the electrolytic cell project, naturally being occupied with the profitability of sodium extraction from NaCl, wanted to determine the NaCl content of common goods. He decided to determine the concentration of sodium chloride of the peanut butter in his pantry.

- c. Describe the process to determine the concentration of NaCl in peanut butter.

6 marks

Total: 14 marks

Question 7

Ethane can be converted to chloroethane when reacted with chlorine gas.

- a. Write a balanced chemical equation representing this reaction. Be sure to include any other condition necessary for this reaction to occur.

2 marks

- b. Using the equation, write the expression for the equilibrium constant for this reaction.

1 mark

0.340 mol ethane and 0.780 mol chlorine gas were fed into a 4.00 L reaction vessel and, under the necessary conditions, were allowed to react until they reached equilibrium. In the equilibrium mixture, there was 0.1114 mol chloroethane present.

- c. Determine the value of the equilibrium constant.

4 marks

- d. A heterogeneous catalyst was added to the reaction vessel before the reactant gases were fed in. Describe how reaction rate and ultimate yield would be affected. In your answer, explain the mechanism by which the catalyst achieves this.

4 marks

Total: 11 marks

Question 8

Consider the reaction $\text{Cu(s)} + 2\text{HCl(aq)} \rightarrow \text{CuCl}_2\text{(aq)} + \text{H}_2\text{(g)}$.

An impure copper sample weighing 10.5 g was reacted with excess hydrochloric acid to determine the amount of copper present at STP. If 3410 mL of hydrogen gas was formed when the reaction was complete, what is the percentage by mass of copper in the sample?

5 marks

Question 9

An alternative form of energy production to the traditional combustion of fossil fuels is the hydrogen-oxygen alkaline fuel cell.

- a. Explain how the energy conversion in fuel cells is much more efficient than that involved in the burning of fossil fuels.

3 marks

- b. For the fuel cell, write balanced chemical equations for the following:

i. the reaction occurring at the anode

1 mark

ii. the reaction occurring at the cathode

1 mark

iii. the overall equation for the fuel cell

1 mark

- c. How is a fuel cell different from a primary cell?

2 marks

- d. Provide two limitations or disadvantages for the use of fuel cells.

2 marks

Total: 10 marks

End of Booklet