ACCESS EDUCATION

VCE Chemistry 2022

Unit 3 & 4 Trial Examination

Assessment Guide

Multiple Choice Answers and Suggested Solutions

SECTION A - Multiple Choice Questions

Question	Answer	Explanation
1	**D**	
2	**C**	2 reactants, 1 product, no waste
3	**D**	OH has precedence over triple
4	**B**	
5	**D**	One proton available for donation from the COOH present
6	**D**	
7	**B**	
8	**C**	
9	**C**	(1.15x1.3+0.85x2.6+.24x13)x37
10	**C**	Pasta has 2.2g of fat vs 1.5g for fried rice… therefore is not twice the energy content due to fat
11	**A**	Butanoic acid has H-Bonding, the others have dipole-dipole only.
12	**A**	Despite having a larger Mr than palmitic the double bond means it may has kinks that make it harder to pack together
13	**B**	(3.2/86)x8.31x(120+273)/150
14	**D**	Exo and coefficient of 2
15	**B**	Based on R groups
16	**C**	
17	**B**	
18	**C**	
19	**C**	
20	**D**	
21	**A**	Component A being closest to the origin is *most* strongly adsorbed to the stationary phase.
22	**C**	
23	**D**	
24	**B**	1.1x29.6=32560kJ 50% loss so 16280/(100x4.18) =ΔT = 38.9 so Tf = 58.9
25	**B**	oxidation
26	**D**	
27	**D**	
28	**A**	
29	**D**	
30	**B**	96500x(10/63.5)x2/10.0 =3039s = 50.7 min

SECTION B – Suggested Solutions

Instructions for Section B

Answer **all** questions in the spaces provided. Write using blue or black pen. No white out

To obtain full marks you should:

- give simplified answers, with an appropriate number of significant figures to all numerical questions; 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
- make sure chemical equations are balanced and that the formulas for individual substances include indication of state; for example; e.g. $H_{2(g)}$, $NaCl_{(s)}$
- unless otherwise indicated, the diagrams in this exam are not drawn to scale.

Question 1 (7 marks)

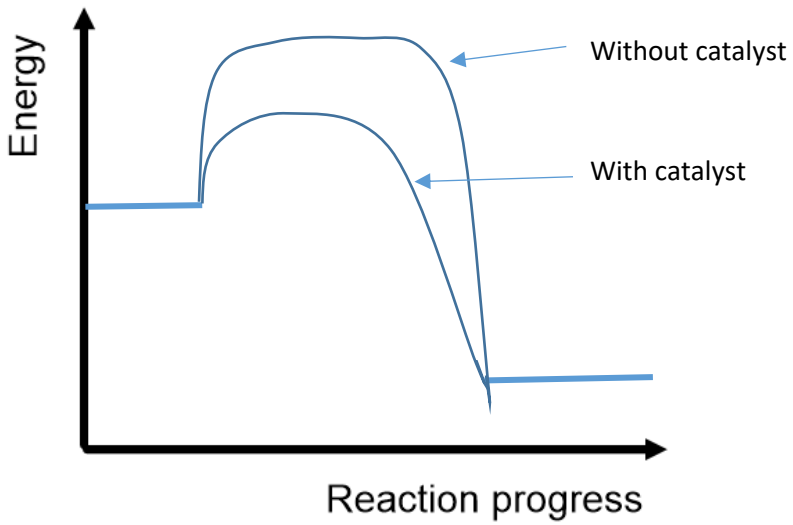
Chemical reactions are occurring around us all the time. Some are reasonably slow, like metal rusting, and some are extremely fast, like the deployment of an airbag in a car crash. Chemists use catalysts to speed up the rate of reaction.

a. Name two other factors that a chemist could change to increase the rate of a chemical reaction

Increase any two of: temp, pressure, concentration, surface area

2 marks

b. On the graph below, draw two energy profile diagrams for an exothermic reaction; one with a catalyst, one without a catalyst.



Exact values aren't required, but needs to be lower on RHS. Graph should be labelled. 2 marks

c. Using the language of collision theory, explain how a catalyst increases the reaction rate. In your answer refer to reaction pathways and activation energy

Catalysts lower activation energy (1 mark) by helping particles line up in correct orientation (1 mark). More collisions in the correct orientation increase the rate of reactions (1 mark).

Teacher to interpret answers roughly against the 3 marks allocated. 3 marks

Question 2 (9 marks)

Energy consumption continues to grow on a global scale. The introduction of alternative energy sources is a major component of research worldwide. However, until infrastructure catches up for alternative fuels, petrol will be part of the fuel puzzle for a few more years.

a. The main component of petrol is octane.

Write a balanced thermochemical equation for the combustion of octane.

$2C_8H_{18(l)} + 25\ O_{2(g)} \rightarrow 16CO_{2(g)} + 18H_2O(l) \quad \Delta H = -10920 kJmol^{-1}$

1 mark for equation, including states and 1 mark for ΔH 2 marks

The 60L fuel tank of a popular Australian made family car holds 42.2 kg of octane.

b. i. If a petrol engine has a maximum fuel efficiency of 25%, what is the maximum amount of useful energy that can be obtain from one tank of fuel. Assume the tank is completely emptied.

$42.2 \times 10^3 \times 47.9 = 2021380 kJ$

25% Efficiency so /4 = 505345kJ or 5.1×10^5 kJ or some variant that equivalent

2 marks

ii. What volume of carbon dioxide gas would one tank of fuel produce if it were measured at 85.0 °C and 235 kPa?

$n(oct) = 42.2 \times 10^3 / 114$

$n(CO2) = 8 \times n(oct) = 2961.4$

$V = 2961.4 \times 8.31 \times (85+273)/235 = 37500 L$ (3s.f.)

2 marks

Ethanol can be used as a substitute for petrol, or it can be blended with petrol. Ethanol provides about 62% of the energy content of petrol based on weight, but has the advantage that it can be produced from renewable sources as bioethanol. Currently there are a number of blended fuels sold to the public; E10 is a petrol blend that is 10% ethanol.

c. If the car's fuel tank was filled with E40, what would be the total amount of energy available from the E40 fuel? (assume percentage by mass to calculate this question) Give your answer in GJ.

$42.2 \times 10^3 \times 0.6 \times 47.9 = 1212828$

$42.2 \times 10^3 \times 0.4 \times 29.6 = 499648$

Total energy =1712476kJ = 1.7GJ 2 marks

d. The benefits of bioethanol as a transport fuel include lower carbon emissions and less particulate pollutions.

What is one disadvantage of bioethanol as transport fuel in cars?

Farm land that could be used for crops being used for fuel production

High levels of ethanol can damage older engines

1 mark

Question 3 (7 marks)

The production of glucose, the primary source of energy in all plants and animals, is through a process called cellular respiration. Through a series of steps glucose is oxidised by oxygen. In this process one mole of glucose produces 2860 kJ of energy. If there is a lack of oxygen when exercising, muscles can extract energy directly from glucose. This process, called anaerobic respiration, leads to the production of the lactate ion and one mole of glucose produces 120 kJ.

a. Write a balanced thermochemical equation to represent the overall redox process of cellular respiration.

$C_6H_{12}O_{6(aq)} + 6O_{2(g)} \rightarrow 6CO_{2(g)} + 6H_2O(l) \quad \Delta H = -2860\ kJmol^{-1}$

1 mark for equation, 1 mark for ΔH 2 marks

In yeast, anaerobic respiration leads to the production of ethanol and carbon dioxide.

b. i. Write a balanced chemical equation for anaerobic respiration in yeast.

$C_6H_{12}O_{6(aq)} \rightarrow 2C_2H_5OH_{(aq)} + 2CO_{2(g)}$

2 marks

ii. If 500.0g of glucose is consumed by the yeast, what volume of carbon dioxide gas will be produced if the reaction takes place at SLC?

n(gluc) = 500/180

n(CO2) = 2xn(glu) = 1000/180 = 5.5555

V= 24.8x5.555 = 138L (3 s.f.)

2 marks

iii. Explain why the CO_2 produced is considered to have negligible environmental impact.

Glucose produced by plants, so CO_2 taken out of the atmosphere.

1 mark

Question 4 (6 marks)

Methanol is used as a car racing fuel. One method of production is by reacting carbon monoxide and hydrogen according to the following reaction One such system has the following equilibrium equation

$CO_{(g)} + 2H_{2(g)} \leftarrow \rightarrow CH_3OH_{(g)} \qquad \Delta H = -91\ kJmol^{-1}$

a. Write an expression for the equilibrium constant K_c.

$K_c = [CH_3OH]/[CO][H_2]^2$

1 mark

b. One way to increase the yield is to add more carbon monoxide. Use La Châtelier's principle to explain why this is.

Le Châtelier's principle states that if change is made to a system at equilibrium the system will try to correct the change. By adding more CO, the system will try and remove it. It does this by moving in the forward direction and this makes more ethanol.

Teacher discretion needed to ensure the answer meets the brief.

2 marks

c. What affect would increasing the temperature have on this system. In your answer refer to yield of methanol and rate of reaction.

Increasing the temps will increase the rate of reaction of both the forward and backwards reactions. However, an increase in temperature favours the endothermic back reaction more, so yield of methanol is decreased.

2 marks

A different process to make methanol is to react carbon dioxide and hydrogen to produce methanol and water.

$CO_{2(g)} + 3H_{2(g)} \leftarrow \rightarrow CH_3OH_{(g)} + H_2O_{(l)}$

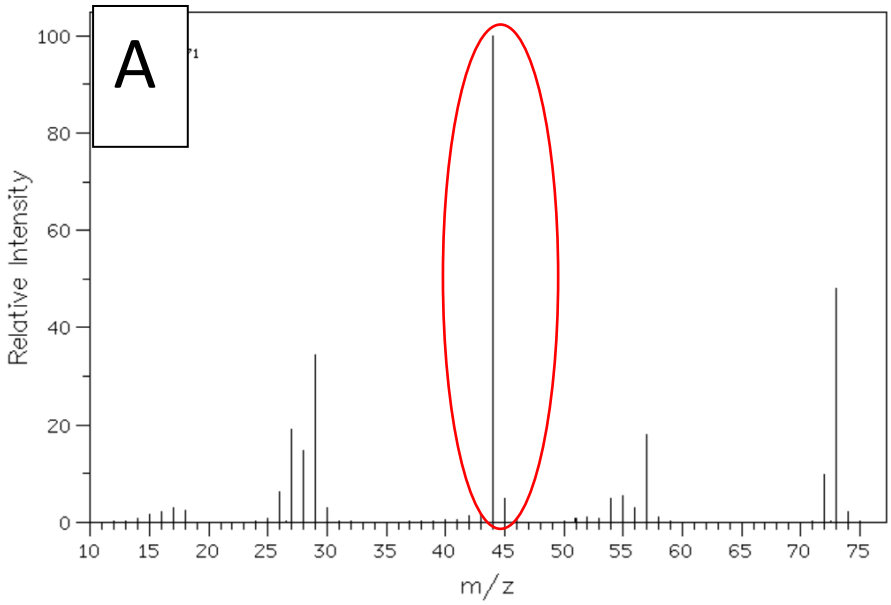
d. Which process will have the higher atom economy

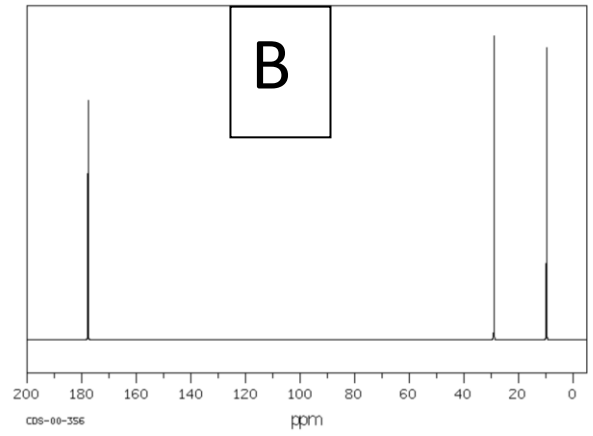
The original reaction has no waste, so it has the higher atom economy (100%).

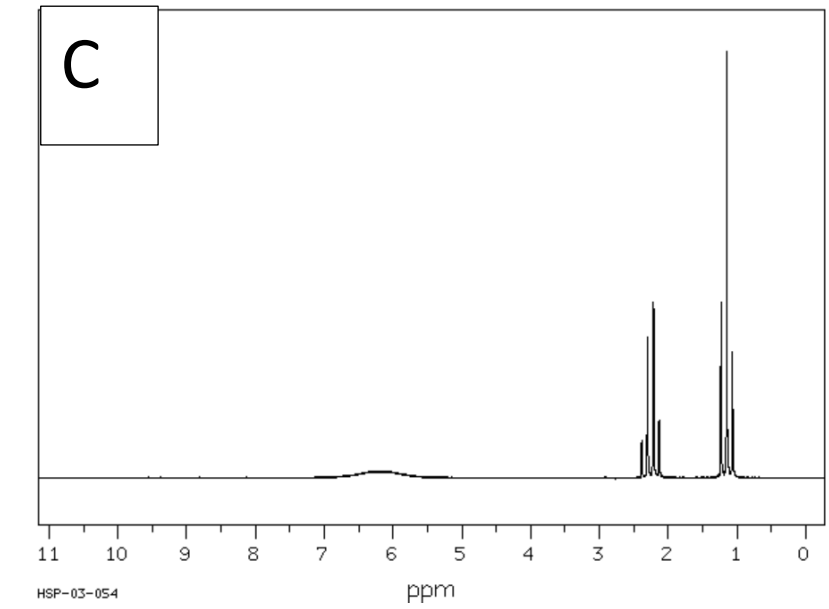
1 mark

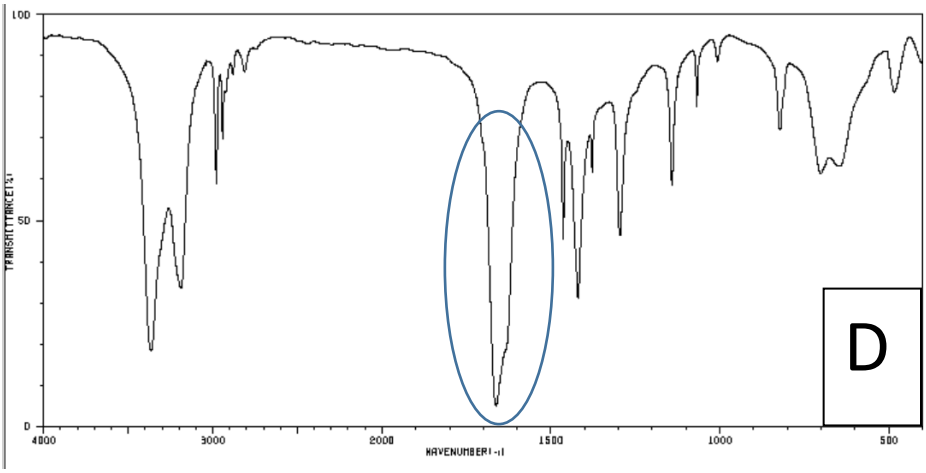
Question 5 (10 marks)

Scientists are asked to determine the structure of an unknown pure organic substance. The molecule is known to contain only carbon, hydrogen, oxygen and nitrogen. A number of tests were conducted and the various spectra are shown before labelled A-D.









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

a. Spectra A is the readout from the Mass Spectroscopy. List the other spectra by letter in the following order: IR, ^{13}C NMR, H NMR

DBC

1 mark

b. i. Circle the base peak value on Spectrum A - see graph

1 mark

ii. Draw a fragment that might account for the peak at 29 m/z value

$CH_3CH_2^+$ there may be others, but must have +

1 mark

c. How many carbon environments are there is the unknown molecule? 3

1 mark

d. What type of bond does the circled peak on spectrum D indicate?

C=O (amides)

1 mark

e. What is the molecular mass of the unknown substance? 73

1 mark

f. On spectrum C, the peaks are split into 4 and 3, with respective areas of 2 and 3. Describe what causes the splitting and what specifically this information tells us

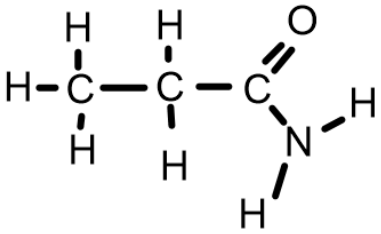
Splitting caused by affect that neighbouring H have. (1 mark)

A group of 2 H is next to 3 H (1 mark)

A group of 3H is next to a group of 2H (1 mark)

3 marks

g. It is known that hydrogens on amide groups are hard to read on a proton NMR spectrum. With that knowledge, and all the other information given, draw the structure of the unknown substance.



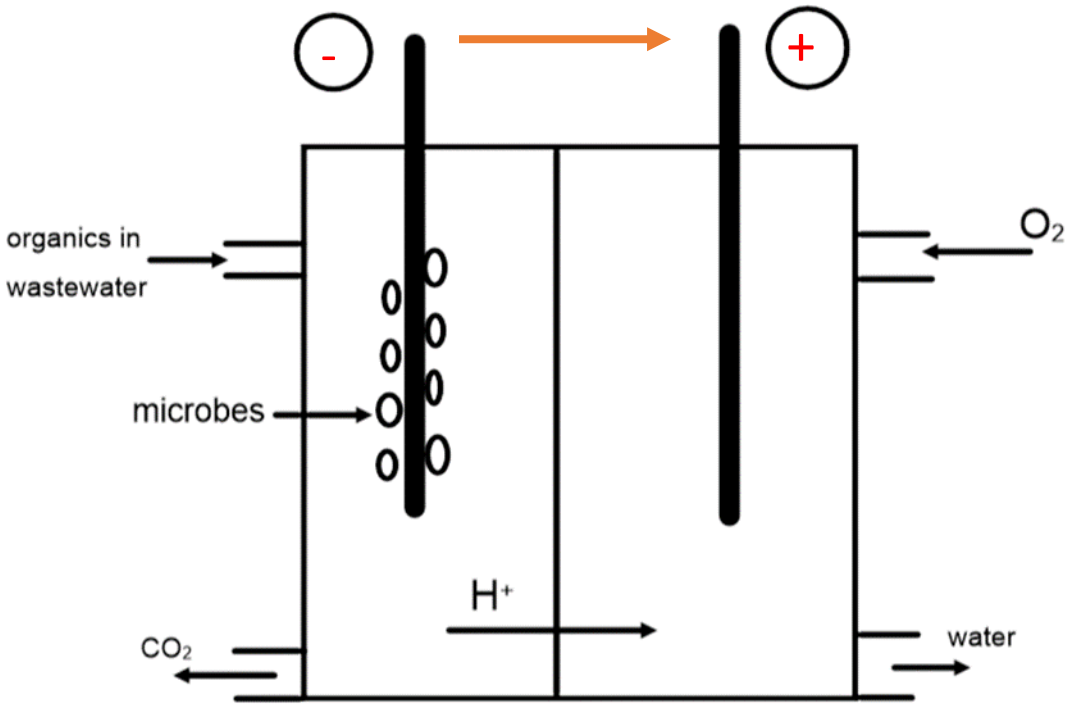
1 mark

Question 6 (9 marks)

Research carried out at the University of Massachusetts into microbial fuel cells (MFC) found that the acetate that is produced from the decomposition of organic matter in lakes and other water bodies can be used to generate electricity and clean water. Whilst carbon dioxide is a by-product of this process, it is still considered a renewable system, as this would have been produced anyway as the plant naturally decomposed.

The acetate (wastewater)half equation is as follows:

$$CH_3COO^-_{(aq)} + 2H_2O_{(l)} \longrightarrow 2CO_{2(g)} + 7H^+_{(aq)} + 8e^-$$



a. Label the polarity of the electrodes by adding + and – in the appropriate circles above.

On graph

1 mark

b. i. Write the half equation that takes place at the cathode

$O_{2(g)} + 4H^+_{(aq)} + 4e^- \rightarrow 2H_2O_{(l)}$

1 mark

ii. Write the overall reaction for this MFC.

$CH_3COO^-_{(aq)} + 2O_{2(g)} + H^+_{(aq)} \rightarrow 2CO_{2(g)}\, 2H_2O_{(l)}$

2 marks

c. Indicate the direction of the electron flow, from one terminal to the other, on the diagram above, with an arrow and label.

On diagram

1 mark

One of the problems found in the research phase was that as the microbe colonies grew bigger, the amount of electricity generated reduced.

b. Give an explanation, in terms of rate of reaction, as to why this might have occurred

Rate of reaction slows down as the particles get bigger as the there is less total surface area per reactant. Or words to that effect

2 marks

e. One potential benefit of this MFC is that heavy metals found in the waste water may be reduced. If it were assumed that this MFC ran at standard conditions, use the electrochemical series to give an example of a heavy metal that might be recovered and state one advantage this would bring.

Gold ions (Au+) has a higher E^0 than the cathode half reaction, so the reduction of gold ions to gold metal would provide additional income if the gold was sold.

2 marks

Question 7 (11 marks)

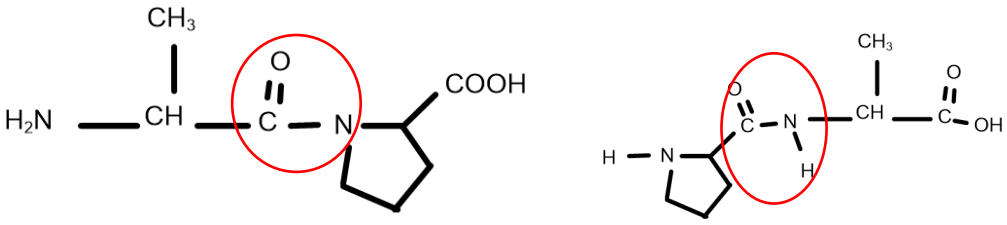
Collagen is the most abundant structural protein in animals. It has a triple helix Quaternary structure. All proteins are made from amino acids.

a. Name the link when 2 amino acids form a dipeptide.

Peptide link/bond

1 mark

b. Draw a diagram using proline and alanine to show that there are two ways that two amino acids can combine. Circle the link from part a.



Only one circle required for 1 mark, other 2 marks for 2 combinations.

1 mark

c. Describe, generally, how a quaternary structure is different to the tertiary structure?

Quarternary involves 2, or more, different polypeptide chains (1 mark) and/or ions or other non-protein molecules (1 mark)

Reference to tertiary structure (1 mark)

Teacher discretion required.

3 marks

Collagen starts to denature at around 70 °C.

d. Describe the difference between denaturation and hydrolysis of proteins. In your answer ensure you reference the primary structure as well as the tertiary and/or quaternary structure.

Denaturation involves breaking of hydrogen bonds /dipole bonds/ dispersion forces in tertiary or quaternary structure (1 mark) caused by change in pH, heat, physical force (1 mark).

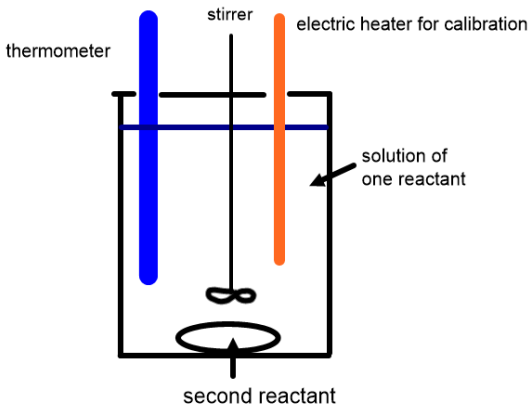
Hydrolysis is the breaking of the peptides chains into smaller peptides or amino acids (1 mark) this is an enzyme catalysed reaction (1 mark).

4 marks

Question 8 (8 marks)

A solution calorimeter is used to measure the energy change when two reactants mix in a solution. Before it can be used it must be calibrated.

When 5.0 volts was passed through the heater using a current of 4 amps for 2.0 minutes, the temperature rose 16.0 °C.



a. Calculate the calibration factor for this calorimeter. Ensure you give the appropriate units.

CF = 5x4x120/16

= 150 J/°C

2 marks

b. i. When 2.04g of glucose is dissolved in the water of the calorimeter, the temperature dropped by 1.45 °C. Is the dissolution exothermic or endothermic?

Endothermic 1 mark

ii. Calculate the enthalpy of solution, in $kJmol^{-1}$,

E = CFx ΔT= 150x1.45 = 217.5 J

n = 2.04/180 = 0.01133

ΔH = 217.5/0.0113333 = 19191.1 = 19.2 $kJmol^{-1}$ (3s.f.)

2 marks

A bomb calorimeter can be used for combustion reactions. A particular bomb calorimeter has a calibration factor of 6.03 kJ/°C. This calorimeter was used to burn a corn chip. The mass of the corn chip 2.75g initially. The temperature of the water rose 3.42 °C. There was 0.82g of corn chip residue and ash left over at the end.

c. Determine the energy content of the corn chip. Give your answer in kJ/kg.

E = 6.03 x 3.42 = 20.6226kJ

Mass of chop burnt = 2.75 – 0.82 = 1.93g = 0.00193

Energy content = 20.6226/0.00193 = 10685 kJ/kg =11000kJ/kg (2 s.f.)

3 marks

Question 9 (11 marks)

Organic molecules are found in all aspects of 21st century life; from cosmetics and cleaning products to medicines and health food supplements. Many occur naturally in plants, others are manufactured using crude oil as the base material.

a. i. Name the following molecule $CH_3CH(NH_2)CH_2CH(OH)CH_3$

4-aminopentan-2-ol

1 mark

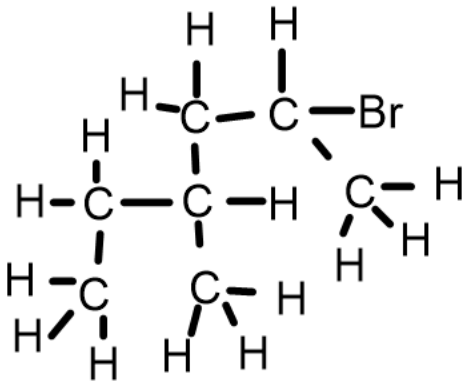
ii. How many chiral centres does the molecule in **a.i.** have? 2

1 mark

iii. Write the semi-structural formula of 2, 4, 4, trifluorobutanoic acid

$CHF_2CH_2CHFCOOH$ or $CHOOCHFCH_2CHF_2$

1 mark



iv. Write the IUPAC name of the compound above

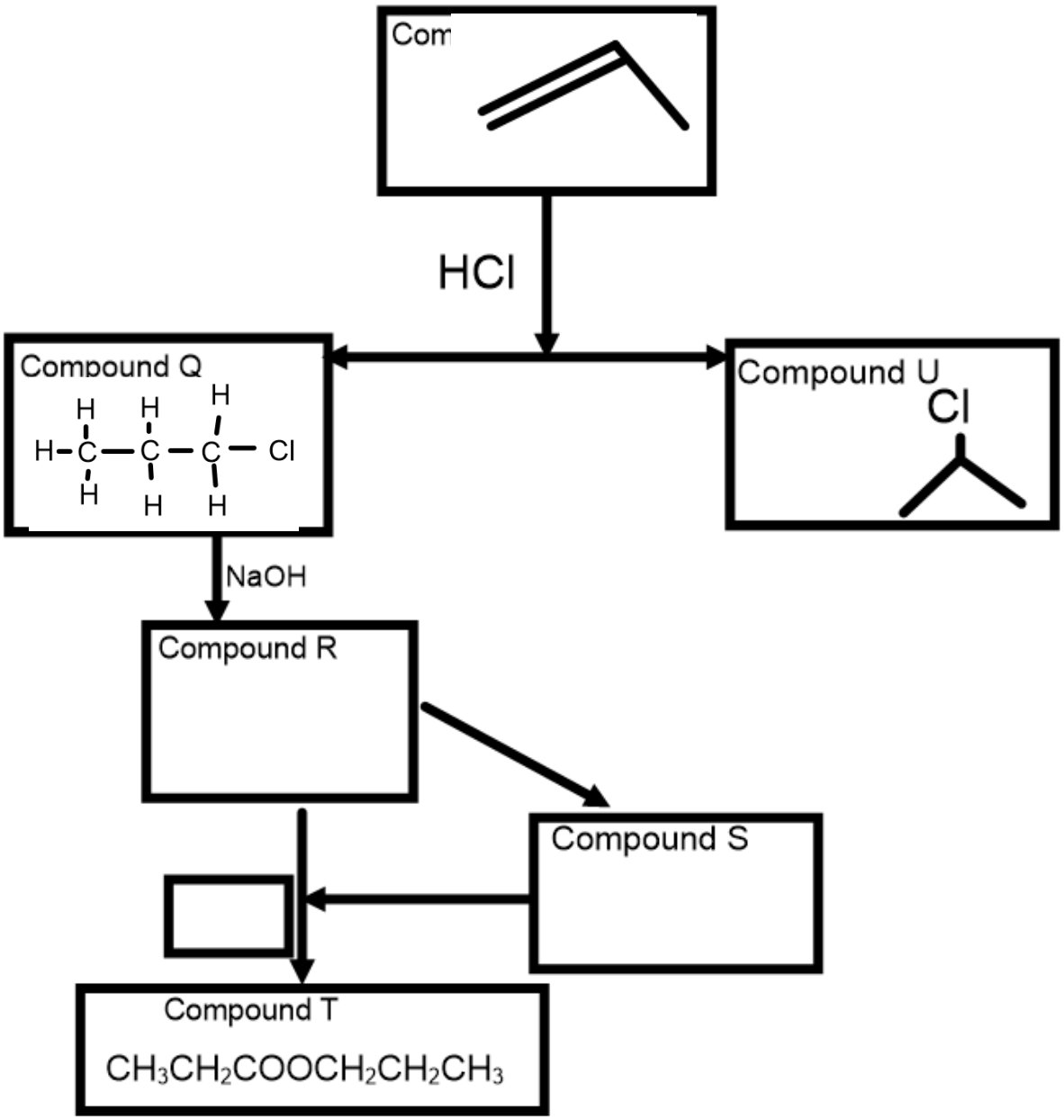
2-bromo-4-methylhexane

1 mark

v. How many chiral centres does the molecular in **a.iv**. have? 2

1 mark

b. Starting with an alkene, the follow reaction pathway takes place. Compound P reacts with HCl to form an approximate 50:50 split of compound U and compound Q



b.i. Name compound U.

2-chloropropane

1 mark

ii. Draw the sitck diagram for compound - P in the box

1 mark

iii. Draw the structural formula of compound Q in the appropriate box. In box 1 mark

iv. Compound Q is reacted with aqueous sodium hydroxide. Give the name of the hommologous series that compound R belongs to. Alcohol or alkanol 1 mark

v. Compound R is separated into two equal streams. One of those streams is reacted with an oxidising agent to form compound S, a carboxylic acid. State the conditions that ensure a carboxylic acid, and not an aldehyde, is produced.

Acidified MnO_4^- or $Cr_2O_7^{2-}$ and heat

1 mark

vi. Compound S and the second stream of compound R are reacted to form compound T. What catalyst is used in this step to speed up the reaction? Write your answer in the appropriate box.

H^+ or H_2SO_4 1 mark

Question 10 (12 marks)

A year 12 student wants to determine the ethanoic acid concentration of a supermarket generic vinegar. They plan to titrate a sample of the vinegar against sodium hydroxide. The concentration of the sodium hydroxide is determined by first titrating it against a standard solution.

a. List two criteria that a primary standard must have:

Any 2 of:

- Readily obtainable in pure form
- Known chemical formula
- Easy to store without breaking down or reacting with atmosphere
- High molar mass
- Inexpensive

2 marks

Sections from the procedure and results are shown in the boxes below.

Procedure

1. Dilute the vinegar by pipetting 25.00mL into a 250mL volumetric flask. Half fill the flask with de-ionised water and shake it. Add more de-ionised water until the bottom of the meniscus is sitting on the calibration line.
2. Fill a burette with standardised sodium hydroxide. Record the initial burette reading.
3. Take a 10.00 mL aliquot of the diluted vinegar and add it to a 100mL conical flask. Add 3 drops of phenolphthalein.
4. Place the flask under the burette on a white tile and titrate until the end point is reached.
5. Record the final burette reading.
6. Repeat steps 3-5 until 3 concordant titres have been obtained.

b. The procedure makes no mention of rinsing the glassware before using it? List the five pieces of glassware and with what each one should be rinsed.

- 25mL pipette – original vinegar
- 250mL flask – deionised water
- Burette – NaOH
- 10mL pipette – diluted vinegar
- Conical flask – deionised water

All 5 = 3 marks, 4 = 2 marks, 2 or 3 = 1 mark

3 marks

c. Write a balanced equation for the reaction between ethanoic acid and sodium hydroxide?

$C_2H_5OH_{(aq)} + NaOH_{(aq)} \rightarrow C_2H_5ONa_{(aq)} + H_2O_{(l)}$

1 mark

Results

Sample	Initial Burette reading	Final burette reading
A	1.75	8.20
B	8.20	14.40
C	14.40	20.50
D	20.50	26.65

d. Using the results table above, calculate the average titre of sodium hydroxide used during the titrations.

3 concordant titres of 6.20, 6.10 and 6.15 for an average of 6.15 mL

1 mark

e. Given that the concentration of the standardised sodium hydroxide is 0.11 M, calculate the concentration ethanoic acid in the undiluted vinegar.

n(NaOH) = 6.15/1000x0.11= 0.0006765

n(Eth) = 0.0006765

C(eth 10mL) = 0.0006765/0.01 = 0.06765

C orig = 0.06765 x 250/25

= 0.6765 M

3 marks

f. Having found that the concentration of ethanoic acid in the vinegar is below the value stated on the bottle, the student thinks about exposing the matter on their podcast "Affairs are current". The student seeks advice from the teacher before doing that. The wise teacher gives the student one piece of advice about the scientific method. Assume that the procedure was followed correctly, what advice is the teacher most likely to give to the student?

Repeat the process with the same sample to get at least 3 set of results (1mark)

Repeat the process with a sample from another bottle and again do at least sets (1 mark)

2 marks

END OF ASSESSMENT GUIDE