Neap

Trial Examination 2021

VCE Chemistry Units 3&4

Written Examination

Suggested Solutions

SECTION A – MULTIPLE-CHOICE QUESTIONS

1	A	**B**	C	D	11	A	**B**	C	D	21	**A**	B	C	D
2	A	B	**C**	D	12	A	B	**C**	D	22	A	B	**C**	D
3	A	**B**	C	D	13	A	B	**C**	D	23	A	B	C	**D**
4	A	B	**C**	D	14	A	B	C	**D**	24	**A**	B	C	D
5	A	B	**C**	D	15	**A**	B	C	D	25	**A**	B	C	D
6	**A**	B	C	D	16	A	B	C	**D**	26	A	B	**C**	D
7	A	B	C	**D**	17	A	**B**	C	D	27	A	**B**	C	D
8	**A**	B	C	D	18	**A**	B	C	D	28	A	B	C	**D**
9	A	**B**	C	D	19	A	**B**	C	D	29	**A**	B	C	D
10	A	B	C	**D**	20	A	B	**C**	D	30	A	B	C	**D**

Question 1 B

B is correct. Carboxylic acids and esters have two oxygen atoms per functional group. **A**, **C** and **D** are incorrect. Alcohols, aldehydes and ketones all have one oxygen atom per functional group.

Question 2 C

C is correct. On complete combustion, both fuels produce carbon dioxide and water. **A** and **D** are incorrect. Petrodiesel is a hydrocarbon, whereas biodiesel is an ester. **B** is incorrect. The viscosity of biodiesel in cold weather is much greater than for petrodiesel.

Question 3 B

B is correct. The polar nature of the ester functional group in biodiesel absorbs more moisture than non-polar petrodiesel. **A** is incorrect. Petrodiesel contains more energy per gram than biodiesel but the difference is not as much as a factor of five. **C** is incorrect. The raw materials for biodiesel are gathered using farming, harvesting, transport and chemical industry methodologies and so some environmental impact is inevitable. **D** is incorrect. Petrodiesel is isolated from crude oil using fractional distillation, which uses energy to heat the mixture but does not recover all of the energy used.

Question 4 C

$$n(C_2H_4) = \frac{m}{M} = \frac{56.0}{28.0} = 2.00 \text{ mol}$$

$$n(H_2) = n(C_2H_4) = 2.00 \text{ mol}$$

$$V(H_2) \text{ at SLC} = n \times V_m = 2 \times 24.8 = 49.6 \text{ L}$$

Question 5 C

$$2.0 \text{ L of hexane} = 2.0 \times 1000 \times 0.66 = 1320 \text{ g}$$

$$n(\text{hexane}) = \frac{m}{M} = \frac{1320}{86} = 15.35 \text{ mol}$$

$$\text{energy released} = 15.35 \times 4163 = 63\,897 = 6.4 \times 10^4 \text{ kJ}$$

Question 6 A

A is correct. Energy is used to convert $\text{hexane(l)} \rightarrow \text{hexane(g)}$. If the hexane has already been converted to a gas, more energy will be released on combustion. That is:

$\text{hexane(g)} \rightarrow \text{hexane(l)} \quad \Delta H < 0$

$\text{hexane(l)} + O_2(g) \rightarrow CO_2(g) + H_2O(l) \quad \Delta H < 0$

Adding the two reactions together gives a larger negative ΔH for combustion of gaseous hexane.

Question 7 D

D is correct and **C** is incorrect. A catalyst increases the rate of the forward and reverse reactions. **A** and **B** are incorrect. A catalyst has no effect on the yield in the equilibrium mixture, the equilibrium constant or the enthalpy change for a reaction.

Question 8 A

$$n(\text{NaOH}) = c \times V = 3.50 \times 0.572 = 2.002 \text{ mol}$$

1 mol of the amino acid must contain 2 mol of ionisable H atoms; that is, diprotic glutamic acid.

Question 9 B

Oxidising 4 mol of Y(s) produces 80.0 kJ of energy. Decomposing the oxide to produce 0.20 mol of Y(s) absorbs $80 \times \frac{0.20}{4} = 4.0$ kJ of energy.

Question 10 D

D is correct. The spiral shape refers to the secondary structure that arises due to the hydrogen bonding of atoms in the peptide bond of amino acid residues near to, but not adjacent to, each other. **A**, **B** and **C** are incorrect. These refer to bonding in the tertiary structure of a protein.

Question 11 B

B is correct. The double bond near the left-hand end of the molecule cannot form *cis-trans* isomers as both substituents on the first carbon are the same. The other double bond can be *cis* configuration or *trans* configuration and so the number of *cis-trans* isomers is two.

Question 12 C

$n(\text{H}_2) = 2 \times n(\text{compound}) = 10$ mol

$pV = nRT$ and so $V = \frac{nRT}{p} = \frac{10 \times 8.31 \times 323}{150} = 178.9 = 1.8 \times 10^2$ L

Question 13 C

C is correct. Accuracy is a measure of the closeness to the real value and precision expresses its reproducibility. The pipette is measuring about 0.5 mL below the real value, but the measurements are reasonably close to each other; that is, low accuracy and high precision.

Question 14 D

D is correct. Random error is manifested in values above and below the real value and is usually reduced, but not removed, by taking an average of the measured values. Systematic error is often due to an incorrect calibration of a piece of equipment and is not remedied by taking repeated measurements and averaging. The pipette gives consistently incorrect readings below the real value and so it is an example of systematic error.

Question 15 A

A is correct, and **B** and **D** are incorrect. Coenzymes are non-protein molecules, often derived from vitamins, and are organic molecules that bind to the active site of enzymes during catalysis. **C** is incorrect. The primary structure of proteins is unaffected when denaturation occurs.

Question 16 D

D is correct and **B** is incorrect. The omega-3 fatty acid has a C=C bond at the methyl end of the molecule. **A** is incorrect. The omega-3 fatty acid has at least two double bonds per molecule: a C=C bond in the hydrocarbon chain and a C=O bond in the carboxyl group. **C** is incorrect. Fatty acids do not have three carboxyl groups per molecule.

Question 17 B

B is correct. In $CH_3CHClCH_2CH_3$, only carbon number 2 has four different groups of atoms attached to it and so only this carbon is chiral.

Question 18 A

error = 7.932 – 7.911 = 0.021

$$\% \text{ error} = \frac{0.021}{7.932} \times 100 = 0.26\%$$

As the value obtained by subtraction, 0.021, has only two significant figures, the answer is given to only two significant figures.

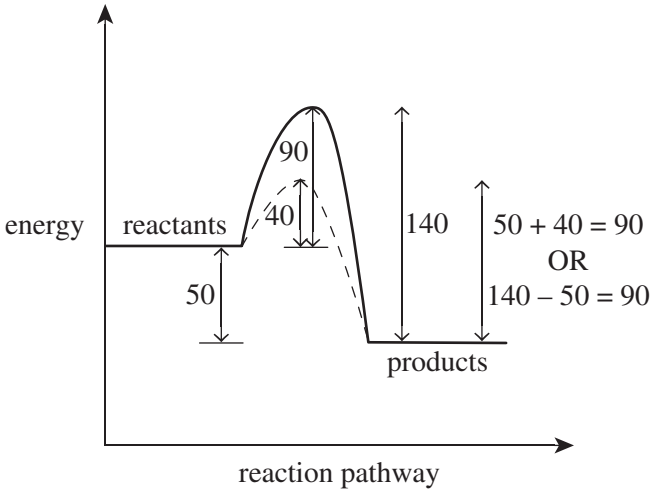
Question 19 B

$$E = \text{CF} \times \Delta T = 3.90 \times 2.80 \text{ kJ}$$

$$\Delta H = \frac{E}{n} = \frac{3.90 \times 2.80}{\frac{0.662}{342}} = 5641 = 5.64 \times 10^3 \text{ kJ mol}^{-1}$$

Question 20 C

C is correct. The ΔH for both the catalysed and uncatalysed reaction is the same. For the uncatalysed reaction, $\Delta H = 90 - 140 = -50$ kJ mol^{-1}. For the catalysed reaction, the activation energy for the catalysed reverse reaction is 40 kJ mol^{-1} plus the magnitude of the ΔH; that is, 40 + 50 = 90 kJ mol^{-1}.



Question 21 A

A is not a necessary step and so is the required answer. This alternative specifies using solvents of different polarities, which implies analysing the mixture by high-performance liquid chromatography (HPLC) several times. This is unnecessary, provided that all of the relevant analyses are completed using identical conditions. **B**, **C** and **D** are all required steps.

Question 22 C

C is correct. The reactant gas, presumably oxygen from the air, must be in contact with the electrolyte. To achieve this, the electrode must be porous and allow oxygen gas to pass through it. The electrode is also likely to be inert so that it does not need replacing. **A** and **D** are incorrect. Aluminium is the negative electrode and so aluminium must be oxidised in a spontaneous redox reaction. **B** is incorrect. There is no evidence in the information that the cell is a secondary cell.

Question 23 D

D is correct. In a fuel cell, all reactants are continuously supplied to the cell, whereas in this cell, only one reactant (oxygen) is continuously supplied. **A**, **B** and **C** are factually correct statements but are not the reason for the description.

Question 24 A

A is correct. The cell reacts aluminium with oxygen using an electrolyte containing hydroxide ions.

Question 25 A

A is correct, and **B** and **C** are incorrect. Due to the branching in the molecule and thus greater exposure to the enzyme, amylopectin is hydrolysed much faster than amylose, which is unbranched. As a result, foods with high amylopectin content have a much higher glycaemic index value, as glucose is readily produced and available to enter the blood. **D** is incorrect. Cellulose is not digested in the human body.

Question 26 C

C is correct, and **A** and **B** are incorrect. Vitamin D can be made in the human body and is a fat-soluble vitamin due to its lack of polar groups in the structure. **D** is incorrect. Vitamin D is neither a protein nor a catalyst.

Question 27 B

$\text{energy in 100 g of bread} = (45 \times 16) + (5 \times 37) + (10 \times 17) = 1075 \text{ kJ}$

$\text{energy in 100 g of cheese} = (3 \times 16) + (29 \times 37) + (21 \times 17) = 1478 \text{ kJ}$

$\text{mass of cheese that contains 1075 kJ} = \frac{1075}{1478} \times 100 = 72.7 \text{ g}$

Question 28 D

D is correct and **A** is incorrect. Increasing the temperature will flatten the distribution curve and increase the area under the curve to the right of the E_a, resulting in more reactant particles that will collide successfully. **B** is incorrect. The area under both curves is identical as the number of particles has not changed. **C** is incorrect. A catalyst will decrease the E_a but not change the shape of the curve.

Question 29 A

A is correct. At the start of the experiment, the amount of each reactant gas drops by 0.02 mol and the product gas increases by 0.04 mol. It seems that the reaction is of the type $X(g) + Y(g) \rightarrow 2Z(g)$. This is also consistent with the response to the change made at 200 seconds.

As the $K_c = \frac{[Z]^2}{[X][Y]}$, there will be no units for the equilibrium constant.

Question 30 D

D is correct. The gradual change in the amounts of gases in the system and the re-establishment of equilibrium indicates that a temperature change is most likely to have occurred. **A** is incorrect. Adding an inert gas will increase the total pressure in the vessel but will not change the position of equilibrium nor the amounts of reactants or products. **B** is incorrect. A catalyst will increase the rate of change of the amount of each gas, but will not alter the position of equilibrium. **C** is incorrect. Changing the volume of the vessel would not change the position of equilibrium as there are two moles of gas on each side of the reaction.

SECTION B

Question 1 (11 marks)

a. Air, rather than pure oxygen gas, is used. 1 mark

Pure oxygen gas is expensive, whereas air has no cost, so it is cheaper for the manufacturer to use air. 1 mark

b. **i.** High pressure results in the molecules being held in a smaller volume, so more frequent collisions will occur. 1 mark

More frequent collisions result in a higher number of successful collisions, so the products are formed at a higher rate. 1 mark

By Le Chatelier's principle, high pressure will favour the pressure-reducing direction. 1 mark

This is the reverse reaction, as this reaction results in less particles and so is pressure-reducing. 1 mark

High pressure produces a higher rate but a lower yield. In addition, it is costly to produce and maintain high pressures. With moderate pressure and the use of a Pt/Rh catalyst, a reasonable rate and yield of reaction are achieved at a lower cost than using high pressure. 1 mark

ii. As the temperature increases, the value of the K_c decreases; that is, in the equilibrium fraction, the numerator decreases and the denominator increases, so the concentration of the products has decreased and the concentration of the reactants has increased. 1 mark

By Le Chatelier's principle, when the temperature increases and the reverse temperature-reducing reaction is favoured, the reaction must be exothermic. 1 mark

c. The oxidation number of N changes from +4 in NO_2 to +5 in HNO_3 *(and the oxidation number of O changes from 0 in O_2 to –2 in HNO_3)*. 1 mark

An increase in oxidation number indicates that a species is the reducing agent; that is, NO_2. 1 mark

Question 2 (11 marks)

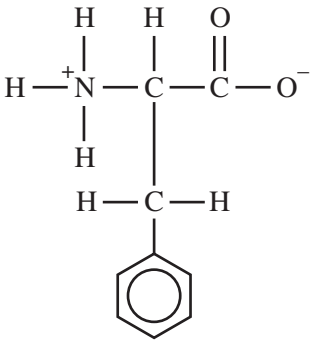
a. **i.** $C_{12}H_{22}O_{11} + H_2O \rightarrow 2C_6H_{12}O_6$ 1 mark

ii. glycosidic (or ether) linkage 1 mark

b. **i.** Sucrose and aspartame contain about the same amount of energy per gram, but aspartame has much greater sweetness. 1 mark

To achieve the same level of sweetness as a certain mass of sucrose, much less aspartame is used and so less energy is consumed, which assists a person to maintain a set body weight. 1 mark

ii.



2 marks
1 mark for correct structure showing all bonds.
1 mark for correctly charged N and O atoms.

iii. An optical isomer has the same constituent atoms but is a mirror image of the original compound structure. 1 mark

If a carbon atom in the original compound structure has four different groups of atoms attached, the optical isomer is not superimposable on its mirror image. 1 mark

c. i. Sucrose is extracted from plants, which can be regrown indefinitely, so sucrose is a renewable resource that can be used to produce ethanol – a fuel from a living source; that is, a biofuel. 1 mark

ii. $C_2H_4(g) + H_2O(g) \rightarrow C_2H_5OH(g)$ 2 marks

1 mark for correct reactants and products.
1 mark for correct states.

Question 3 (9 marks)

a. i. positive anode *(oxidation of I^- occurs)* 1 mark

ii. $2I^-(aq) \rightarrow I_2(aq) + 2e^-$ 1 mark

b. i. $2H_2O(l) + 2e^- \rightarrow 2OH^-(aq) + H_2(g)$ 1 mark

ii. As hydroxide ions are produced, the solution becomes more alkaline near the electrode. Increasing alkalinity results in an increased pH. 1 mark

c. i. $n(S_2O_3^{2-}) = c \times V = 0.065 \times 0.02850 = 1.8525 \times 10^{-3}$ mol 1 mark

$n(I_2) = \frac{1}{2} \times n(S_2O_3^{2-}) = 9.263 \times 10^{-4} = 9.3 \times 10^{-4}$ mol 1 mark

ii. $n(e^-) = 2 \times n(I_2) = 1.8525 \times 10^{-3}$ mol 1 mark

amount of charge, $Q = n(e^-) \times F = 1.8525 \times 10^{-3} \times 96\ 500 = 178.8 = 1.8 \times 10^2$ C 1 mark

iii. $Q = I \times t$ and so:

$178.8 = 2.5 \times t$

$t = 71.52 = 72$ s 1 mark

Question 4 (9 marks)

a. **i.** methyl ethanoate 1 mark

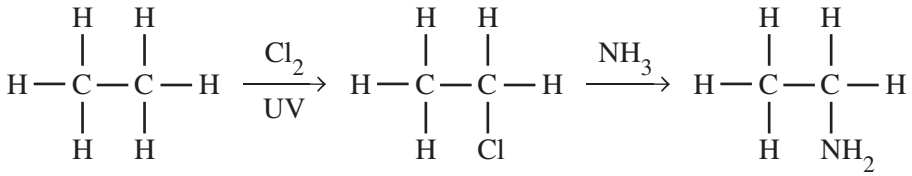
ii. esters 1 mark

iii. The reactants are liquid methanol and liquid ethanoic acid, 1 mark
heated (under reflux conditions) with sulfuric acid as a catalyst. 1 mark

iv. $\%\ \text{atom economy} = \dfrac{M(\text{Z})}{M(\text{X}) + \text{M(Y)}} \times 100$ 1 mark

$= \dfrac{74.0}{92.0} \times 100 = 80.4\%$ 1 mark

b.



ethane chloroethane ethanamine

3 marks
1 mark for showing that ethane is reacted with chlorine gas using ultraviolet light.
1 mark for showing that one organic product is chloroethane.
1 mark for showing that chloroethane is reacted with ammonia to produce ethanamine.

Question 5 (5 marks)

a. $K_c = \dfrac{[CF_4][CO_2]}{[COF_2]^2}$ 1 mark

b.

	$\mathbf{2COF_2}$	$\mathbf{CF_4}$	$\mathbf{CO_2}$
$\boldsymbol{n_i}$	1.00	0	0
Change	–0.80	+0.40	+0.40
$\boldsymbol{n_e}$	0.20	0.40	0.40
$\boldsymbol{c_e = \dfrac{n}{5.0}}$	0.040	0.080	0.080

3 marks
1 mark for each correct concentration.

$K_c = \dfrac{0.080 \times 0.080}{0.040^2} = 4.0$ 1 mark

Question 6 (11 marks)

a. **i.** $2Ag^+(aq) + Zn(s) \rightarrow 2Ag(s) + Zn^{2+}(aq)$ 2 marks

1 mark for correct reactants and products.
1 mark for correct balancing and states.

ii. Silver ions are stronger oxidising agents than the conjugate oxidising agent of zinc (Zn^{2+}). The stronger oxidising agent (Ag^{+}) and the stronger reducing agent (Zn) are mixed and so they should react. 1 mark

iii. *For example, any one of:*

Mn, Al, Mg, Na, Ca, K, Li *(any metal with a conjugate oxidising agent that is weaker than zinc ions)* 1 mark

iv. The reaction occurs because zinc atoms collide with silver ions and electrons are transferred to the silver ions. 1 mark

Zinc dust has a much greater surface area than the larger granules, so the reaction will be much faster due to the greater frequency of collisions. 1 mark

v. Prediction of the reaction from the electrochemical series suggests that this is a spontaneous reaction at 25°C. The activation energy barrier is thus overcome at 25°C, indicating that the barrier is quite low. 1 mark

b. i. voltage = +1.09 – (–0.40) = 1.49 V 1 mark

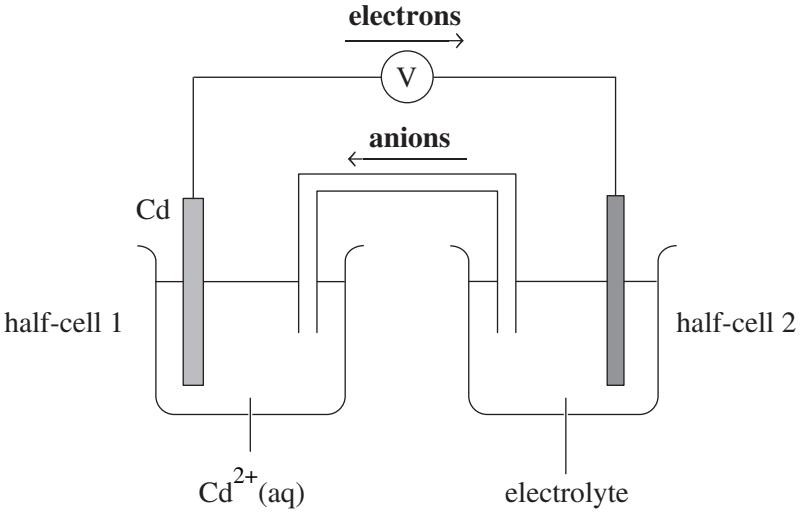
ii. *For example, any one of:*

- graphite
- platinum

1 mark

Note: Accept any inert electrode.

iii. and **iv.**

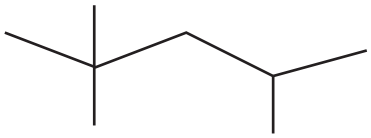


1 + 1 = 2 marks

Question 7 (12 marks)

a. i. $C_{20}H_{42}$ 1 mark

ii.



1 mark

b. $C_9H_{20}(l) + 14O_2(g) \rightarrow 9CO_2(g) + 10H_2O(l) \quad \Delta H = -6.1 \text{ MJ mol}^{-1}$ 3 marks

$(48 \text{ kJ g}^{-1} = 48 \times 128 = 6144 \text{ kJ mol}^{-1})$

1 mark for correct reactants and products.
1 mark for correct balancing and states.
1 mark for correct ΔH, including sign.

c. All three hydrocarbons are non-polar molecules that have intermolecular dispersion forces. Dispersion forces increase in strength as molecule size increases within a homologous series. 1 mark

As the molecules increase in size, they are held to each other with greater intensity due to the stronger dispersion forces. More energy is needed to disrupt the bonds, giving a higher boiling point. 1 mark

d. **i.** *For example, any one of:*

- $2C_6H_{14}(l) + 17O_2(g) \rightarrow 2C(s) + 10CO_2(g) + 14H_2O(g)$
- $C_6H_{14}(l) + 5O_2(g) \rightarrow 3C(s) + 3CO(g) + 7H_2O(g)$

2 marks
1 mark for correct reactants and products.
1 mark for correct balancing and states.
Note: Students may provide other examples than those shown.

ii. The yellow flame indicates that there is insufficient oxygen for complete combustion, so some carbon and/or carbon monoxide could be present. 1 mark

The sooty flame with black smoke indicates that carbon particles are present. 1 mark

iii. The flashpoint of a hydrocarbon is the temperature at which a sufficient amount of the hydrocarbon vapour mixes with air to allow ignition. At room temperature, hexadecane will not reach its flashpoint and so no ignition will occur. 1 mark

Question 8 (12 marks)

a. **i.**

Signal	base peak	molecular ion peak
m/z value	**43**	**58**

2 marks
1 mark for each correct value.

ii. C_3H_6O 1 mark

iii. CH_3^+ 1 mark

b. **i.** Two carbon atoms are bonded to the carbon atom that holds the hydroxyl group in a secondary alcohol. 1 mark

ii. C=O or carbonyl functional group *(secondary alcohols are oxidised to ketones)* 1 mark

iii. The strong signal at about 1750–1800 cm^{-1} is typical of the absorption of infrared radiation for the presence of the carbonyl group. 1 mark

c. The data are consistent with the structure of the three-carbon carboxylic acid, CH_3CH_2COOH.

For example, any three of:

- There are three hydrogen environments, as indicated by the number of peaks.
- The peak at chemical shift 11.8 is consistent with the H in the COOH group.
- The peak area shows the ratio of hydrogen atoms in the compound, so for this molecule that ratio is 3 : 2 : 1, consistent with CH_3CH_2COOH.
- The peak splitting indicates the number of hydrogen atoms on adjacent carbon atoms using the $n + 1$ rule. The triplet indicates two hydrogen atoms on the adjacent carbon atom (CH_2), the quadruplet indicates three adjacent hydrogen atoms (CH_3) and the singlet indicates no adjacent hydrogen atoms (the COOH).

3 marks

d. **i.** The chemical shift is a larger scale of 0 to 200 ppm in the carbon-13 NMR compared to 0 to 13 ppm for the proton NMR. 1 mark

ii. The number of signals (excluding TMS) in the carbon-13 NMR spectrum indicates the number of carbon environments. In the spectrum shown, the compound has three different carbon environments. 1 mark

Question 9 (10 marks)

a. **i.** $C_{19}H_{39}COOH$ 1 mark

ii. linolenic acid *($C_{17}H_{29}COOH$ with three C=C bonds)* 1 mark

b. **i.** approximately 35°C *(shortest time for colour change)* 1 mark

ii. At low temperatures, the substrate molecules are moving slower and will not interact with the enzyme molecules as often as at the temperature of maximum activity; that is, breakdown of the substrate is reduced. 1 mark

As the temperature increases above approximately 35°C, the enzyme structure is being progressively disrupted as the weaker bonds in the tertiary structure of the protein are broken. 1 mark

As a result, the active site of the enzyme molecule is disrupted, and the substrate molecules are not able to bind to it. As binding is required for catalysis to occur, the rate of breakdown of the substrate molecules is reduced. 1 mark

iii. To ensure the accuracy and validity of the experiment, the set temperature of the contents of the test tubes must not change. 1 mark

Adding enzyme solution that does not match the set temperature will alter the temperature of the contents slightly and so recorded temperatures will be inaccurate. Changing temperatures also affects the validity of the experiment and its results. 1 mark

iv. The experiment depends on producing data that is affected by the change in pH; that is, the indicator colour changing. 1 mark

Testing the pH dependence of the enzyme would require the contents of the test tubes to be maintained at a set pH, which would prevent the indicator from changing colour. 1 mark