STAV PUBLISHING

STAV Publishing 2021

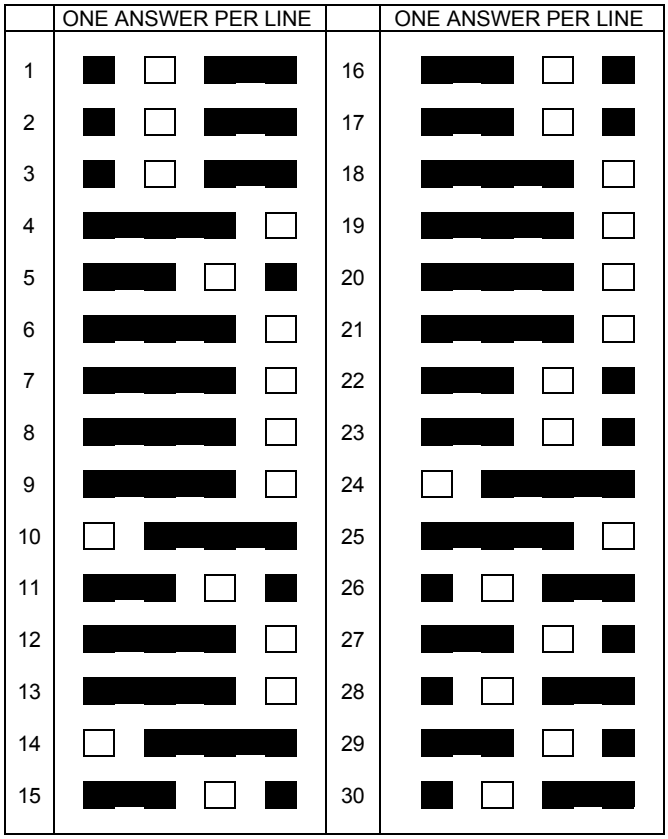
CHEMISTRY
Units 3 & 4
Trial Examination

SOLUTIONS BOOK

Published by STAV Publishing. STAV House, 5 Munro Street, Coburg VIC 3058 Australia.
Phone: 61 + 3 9385 3999 • Fax: 61 + 3 9386 6722 • Email: stav@stav.vic.edu.au Website: http://www.sciencevictoria.com.au/stavpublishing

ABN 61 527 110 823

Use this page as an overlay for marking the multiple choice answer sheets. Simply photocopy the page onto an overhead projector sheet. The correct answers are open boxes below. Students should have shaded their answers. Therefore, any open box with shading inside it is correct and scores 1 mark.



SECTION A (Total 30 marks)

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

Comments for Section A answers

Question 1
Only random errors can be averaged out. Systematic errors are always in the same direction. **Correct Answer: B**

Question 2
A 50.0 mL pipette cannot be used to accurately measure 25.0 mL of solution. It must only be used to measure 50.0 mL of solution. **Correct Answer: B**

Question 3
The products in an endothermic reaction are higher in energy than the reactants. Bonds are less stable i.e. the bonds are weaker. **Correct Answer: B**

Question 4
Reaction occurs only when the particles collide with an energy greater than or equal to the activation energy. The activation energy, shown as X, for the forward reaction is the minimum energy required to break the bonds in the reactants for the reaction to occur. **Correct Answer: D**

Question 5
Less activation energy is needed with a catalyst so X is lowered and as a consequence Z is also lowered. **Correct Answer: C**

Question 6
Two mol of NO releases 114 kJ so 1 mol releases 57 kJ. **Correct Answer: D**

Question 7
M(heptan-1-ol) = $7 \times 12.0 + 16 \times 1.0 + 16.0 = 116$ g mol^{-1}

E per g = $4638 \div 116 = 39.98$ kJ per gram = 3.998×10^4 J per gram

$E = m\,c\,\Delta T$; $m = \frac{E}{c\,\Delta T} = \frac{3.998 \times 10^4}{4.18 \times 25} = 382.6$ g = 0.38 kg; **Correct Answer: D**

Question 8
The reaction slows down because there are fewer molecules of acid colliding with the magnesium per unit time. **Correct Answer: D**

Question 9
As T↑, %X ↓
As P ↑, %X ↑, therefore it favours the side with less molecules to partially offset P↑
In A, T↑, net back reaction to produce more not less N_2 ; also no reaction to pressure change as same number of molecules on both sides. **Not A**
In B, T↑, net back reaction to produce more NH_3 not less; P↑, net back reaction to produce more NH_3 (slightly less total molecules on left partially offsets pressure increase). **Not B**
In C , T ↑, net forward reaction, more NO_2. **Not C**
In D, T↑, net back reaction so less NH_3; less molecules on right. P↑, net forward reaction to produce NH_3 (less total molecules on right partially offsets pressure increase). **Correct Answer: D**

Question 10
The O atoms in hydrogen peroxide are −1 and on the right hand side the O atoms are −2.
Reduction is decrease in oxidation number. **Correct Answer: A**

Question 11
In a galvanic cell, oxidation occurs at the anode. Magnesium is a stronger reducing agent than Ag so the Mg loses electrons so Ag^+ must be reduced. **Correct Answer: C**

Question 12
Need the most mole of CO_2 for the least number of mole of electrons.
methanol: 1 mol CO_2 per 6 mol of electrons.
ethanol: 1 mol CO_2 per 6 mol of electrons.
ethane : 1 mol CO_2 per 7 mol of electrons.
ethane-1,2-diol: 1 mol CO_2 per 5 mol of electrons. **Correct Answer: D**

Question 13
Strongest reducing agent(reductant) are iodide ions so iodine is produced at the anode.
Strongest oxidising agent(oxidant) is water so hydrogen gas is produced at the cathode.
Correct Answer: D

Question 14
An increase in temperature and pressure will both increase the rate. **Correct Answer: A**

Question 15
Since the forward reaction to produce Z is endothermic, it will be favoured by a higher temperature. A lower pressure would favour Z as there are more molecules on the right hand side to partially increase the pressure. **Correct Answer: C**

Question 16
Homologues must have the same functional group and similar chemical properties.
Correct Answer: C

Question 17
A, B and C have a bromine atom. A is a primary, B is a tertiary and C is a secondary.
Correct Answer: C

Question 18
The six 'straight' chain compounds are 1,1 ; 1,2 ; 1,3 ; 1,4 -dichlorobutane and 2,2 ; 2,3-dichlorobutane. **Correct Answer: D**

Question 19
Histidine has 6 C atoms. Aspartic acid has 4 C atoms. Both proline and glutamic acid have 5 C atoms and one basic amino group. Glutamic acid has 2 carboxyl groups which will most likely give it a pH less than 7. **Correct Answer: D**

Question 20
This molecule has the most branching which minimises dispersion forces. **Correct Answer: D**

Question 21
$C_{16}H_{32}O_2$ is saturated with no C/C double bonds
$C_{18}H_{36}O_2$ is saturated with no C/C double bonds
$C_{18}H_{34}O_2$ is unsaturated with one C/C double bond
$C_{18}H_{32}O_2$ is unsaturated with two C/C double bonds **Correct Answer: D**

Question 22
Coenzymes can act as carriers of electrons as well as particular groups of atoms such as –CHO and $–COCH_3$(acetyl). **Correct Answer: C**

Question 23
A chiral carbon must have four different groups attached.
The underlined and bolded C in III, $CH_3CO\underline{\mathbf{C}}H(CH_3)CHO$ is the only carbon which is chiral.
Correct Answer: C

Question 24
$n(GLY) = \frac{m}{M} = \frac{1}{75} = 1.33 \times 10^{-2}$ mol;
Since urea has 2 N atoms and GLY has one N atom, n(urea) = ½ × n(GLY)
$n(urea) = ½ \times 1.33 \times 10^{-2} = 6.66 \times 10^{-3}$ mol
$m(urea) = n \times M = 6.66 \times 10^{-3} \times 60.0 = 0.40$ g **Correct Answer: A**

Question 25
D shows that one unit of the di-acid and one unit of the diol have undergone a condensation reaction with a water molecule being lost. **Correct Answer: D**

Question 26
Cellulose has alternating up glycosidic (ether) links and different orientations of the attached $–CH_2OH$. **Correct Answer: B**

Question 27
As water is lost when the amino acids condense, the oxygen content will be lower.
Correct Answer: C

Question 28
The burette must be rinsed with the solution to be used in it, not water. I and III are correct techniques. **Correct Answer: B**

Question 29

$CH_3COOH + NaOH \rightarrow CH_3COONa + H_2O$ reaction is 1:1

$n(NaOH) = c \times V = 0.600 \times 26.7 \times 10^{-3} = 1.602 \times 10^{-2}$ mol; $n(CH_3COOH) = 1.602 \times 10^{-2}$ mol

$[CH_3COOH] = \frac{n}{V} = \frac{1.602 \times 10^{-2}}{20.00 \times 10^{-3}} = 0.801$ M

in 1 litre, $m(CH_3COOH) = c \times M = 0.801 \times 60.0 = 48.1$ g **Correct Answer: C**

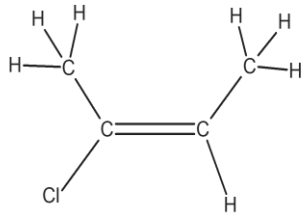
Question 30

ΔT will be higher (less water to heat up, 95 mL not 100 mL) so calculated CF is lower, therefore the actual CF should be higher and the actual heat of reaction should be higher.
Correct Answer: B

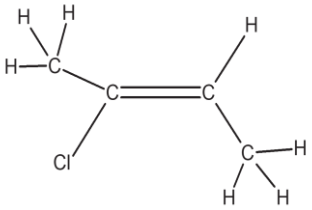
Section B (90 marks)

Question 1 (7 marks)

a.



cis



trans

(1 mark for each correct structure and 1 overall mark for correctly labelling the isomers)

b. **i.** Alkanes do not react with bromine solution and therefore no colour change occurs in the orange-yellow bromine solution **(1 mark)**. Alkenes readily react with bromine solution and decolourise the orange–yellow bromine **(1 mark)**.

ii. Primary alcohols can be oxidised by $Cr_2O_7^{2-}/H^+$ with the dichromate solution changing colour from orange to green as the reaction occurs **(1 mark)**. Tertiary alcohols cannot be oxidised by $Cr_2O_7^{2-}/H^+$ **(1 mark)**.

Question 2 (3 marks)

a. $C_5H_8O_2$ **(1 mark)**

b. Yes, it can be polymerised **(1 mark)**. The presence of the C/C double bond means it can undergo addition polymerisation **(1 mark)**.

Question 3 (12 marks)

- **Step 1**
  Expose propane to UV light **(1 mark)** to produce both 1-chloropropane and 2-chloropane **(1 mark)**.

  $C_3H_8(g) + Cl_2 \rightarrow CH_3CH_2CH_2Cl + HCl$ **(1 mark)**

  $C_3H_8(g) + Cl_2 \rightarrow CH_3CHClCH_3 + HCl$ **(1 mark)** discard 2-chloropropane

- **Step 2**
  Add warm, dilute NaOH(aq) to 1-chloropropane to give propan-1-ol **(1 mark)**

  $CH_3CH_2CH_2Cl + NaOH \rightarrow CH_3CH_2CH_2OH + NaCl$ **(1 mark)**

  Keep half of the propan-1-ol **(1 mark)**

- **Step 3**
  Oxidise the rest of the propan-1-ol to propanoic acid **(1 mark)** using an oxidising agent such as $Cr_2O_7^{2-}/H^+$ **(1 mark)**

  $CH_3CH_2CH_2OH \rightarrow CH_3CH_2COOH$ **(1 mark)**

- **Step 4**
  Warm propanoic acid with propan-1-ol & add concentrated H_2SO_4 **(1 mark)** as a catalyst.

  $CH_3CH_2COOH + CH_3CH_2CH_2OH \rightarrow CH_3CH_2COOCH_2CH_2CH_3 + H_2O$ **(1 mark)**

Question 4 (4 marks)

a. methanamine or methyl amine **(1 mark)**

b. pentan-2-ol or 2-pentanol **(1 mark)**

c. 3-bromobutanoic acid **(1 mark)**

d. 2,4-dimethylpentan-3-ol **(1 mark)**

Question 5 (7 marks)

a. **(Any three of the following for 1 mark each)**
- provide energy, for example glucose
- store energy (glycogen in the liver)
- source of dietary fibre – cellulose
- precursors for other important biological molecules

b. Amylose is a linear polymer of glucose **(1 mark)**. These molecules coil into spiral-like structures which pack together tightly with many –OH groups on the inside and away from contact with water making it virtually insoluble **(1 mark)**. Amylopectin is a branched polymer **(1 mark)** which restricts the coiling of the polymer leaving many more –OH groups exposed to water, allowing hydrogen bonding and thus making it soluble **(1 mark)**.

Question 6 (9 marks)

a. V↑, P↓, LCP says P must partially increase to restore equilibrium. Since there are more molecules on the left side, a net back reaction will occur **(1 mark)** to increase the mole of H_2 **(1 mark)** but the overall $[H_2]$ will be decreased compared with the initial concentration because of the volume increase **(1 mark)**.

b. $2H_2(g) + CO(g) \rightleftharpoons CH_3OH(g)$

NB. Reaction is proceeding in the reverse direction

n_i	0.50	1.0	2.50	
n_r			**0.18**	**(1 mark)**
n_p	**0.36**	**0.18**		
n_e	0.86	1.18	2.32	**(1 mark)**

Need molar concentrations so divide by 2

÷2 $[\ \ ]_e$	0.43	0.59	1.16	**(1 mark)**

$K = \frac{[CH_3OH]}{[H_2]^2[CO]}$ **(1 mark)** $= \frac{1.16}{0.43^2 \times 0.59} = 10.6 = 11$ (2sf) **(1 mark)** M^{-2} **(1 mark)**

Question 7 (17 marks)

a.

	C		H		O	
mol ratio	$\frac{66.7}{12.0}$	:	$\frac{11.1}{1.0}$	:	$\frac{22.2}{16.0}$	**(1 mark)**
	5.56	:	11.1	:	1.39	Divide each by 1.39 **(1 mark)**
	4.0	:	8.0	:	1.0	

i.e. C_4H_8O **(1 mark)**

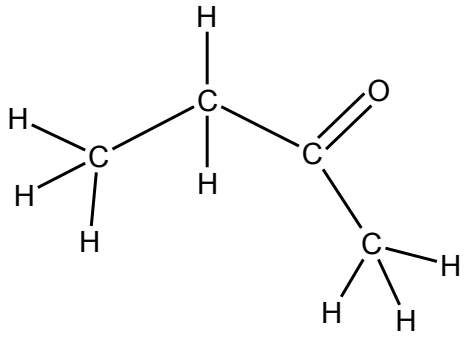
b. **i.** base peak: mass = 43 **(1 mark)** ; formula is $C_2H_3O^+$ **(1 mark)**
ii. parent molecular ion: mass = 72 **(1 mark)** ; formula is $C_4H_8O^+$ **(1 mark)**

c. C_4H_8O **(1 mark)** (Molar mass of C_4H_8O = 72 hence this is also the molecular formula)

d. –C=O peak just over 1700 cm^{-1} **(1 mark)**
–C–H peaks just under 3000 cm^{-1} **(1 mark)**
No broad –OH peak present around 3400 cm^{-1} **(1 mark)**

e. 3 ^1H environments represented by the three peaks in the ^1H NMR spectrum **(1 mark)**
Triplet near 1.0 ppm – these protons are adjacent to CH_2 **(1 mark)**
Singlet (just below 2.2 ppm) – isolated proton(s) **(1 mark)**
Quartet (just below 2.2 ppm) – these protons are next to CH_3 **(1 mark)**

f.



Must have 4C atoms and C=O **(1 mark)**
Must satisfy all previous requirements **(1 mark)**
[Note that the CH_3 next to the C=O is the singlet as the protons are isolated as they are more than three bonds from the nearest H atoms.]

Question 8 (8 marks)

a. $Zn(s) + Cu^{2+}(aq) \rightarrow Zn^{2+}(aq) + Cu(s)$ **(1 mark)**

b. **(any two of the following for 1 mark each)**
- No heat energy is lost to the surroundings.
- The specific heat capacity of $CuSO_4(aq)$ is the same as water.
- Volume of solution is not changed by the addition of zinc.
- Volume remains constant despite the temperature increase.

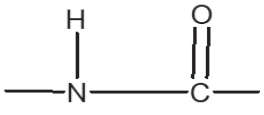
c. **i.** $\Delta T = 75 - 22 = 53°C$ **(1 mark)** (go up from 60 s on the graph to the dashed line at 75°C)
ii. $E = V \times c \times \Delta T = 50.0 \times 4.18 \times 53 = 11\,077\ J = 11\ kJ$ (2 sf) **(1 mark)**

d. $n(CuSO_4) = c \times V = 1.00 \times 0.0500 = 0.0500\ mol$ **(1 mark)**

e. $\Delta H = \frac{\Delta E}{n(Zn)} = \frac{11.1}{0.0500} = -$ **(1 mark)** $2.2 \times 10^2\ kJ\ mol^{-1}$ **(1 mark)**

Question 9 (7 marks)

a.

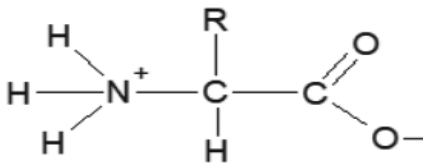


(1 mark)

b. 5 different amino acid residues (alanine is repeated) **(1 mark)**

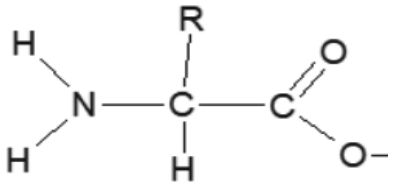
c. alanine, aspartic acid, methionine, alanine, glutamic acid, cysteine
(All correct & in order 3 marks, one error 2 marks, two errors 1 mark, 3 errors 0 marks)

d. (Must have any one of the side branches, R, representing alanine, methionine or cysteine.)



(1 mark)

e.



(1 mark)

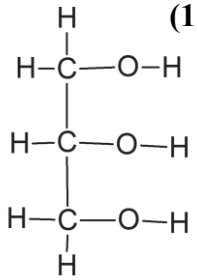
Question 10 (10 marks)

a. The oils have too high a viscosity (**1 mark**) and are not volatile enough to be readily vaporised (**1 mark**) for use in a typical engine. (Methyl/ethyl esters of the acids have a lower viscosity and are more readily vaporised.)

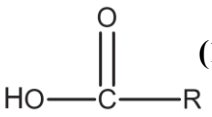
b. (Accept full structural / semi-structural formula for all but the final product.)

(1 mark)

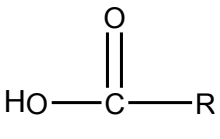
NaOH



(1 mark)



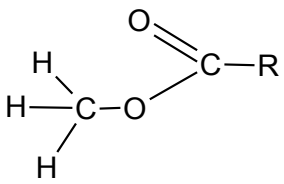
(1 mark)



(1 mark)

CH_3OH

(1 mark)



(1 mark)

(Full structural formula must be shown for final product)

c. Biodiesel can vary in viscosity because the fatty acids can be of different C chain lengths. The longer the chain, the more dispersion forces **(1 mark)**. If the fatty acid has C/C double bonds then it will be less viscous as the molecules cannot get as close to each other **(1 mark)**.

Question 11 (6 marks)

a. $\frac{\text{M(desired product)}}{\text{M(all reactants)}} \times \frac{100}{1} = \frac{60.0}{46.0 + 32.0} \times \frac{100}{1} = 76.9\%$ **(1 mark)**

b. **i.** M(methanol) = 32.0 g mol^{-1} ; n(methanol) = $\frac{m}{M} = \frac{5.2 \times 10^6}{32.0} = 1.625 \times 10^5$ mol **(1 mark)**

n(ethanoic acid) = n(methanoic acid) **(1 mark)** ; n(ethanoic acid) = 1.625×10^5 mol

m(ethanoic acid) = n × M = $1.625 \times 10^5 \times 60.0 = 97.5 \times 10^5$ g = 9.75 tonnes **(1 mark)**

ii. % yield = $\frac{8.5}{9.75} \times 100 = 87\%$ (2 sf) **(1 mark)**

c. **(1 mark for either of the following)**
a very high atom economy means very little waste
or
less purification is required

END OF SUGGESTED SOLUTIONS