Topic Test

Section A – Multiple Choice (20 marks)

1. Which alternative correctly identifies the functional groups for each of the homologous series listed?

	Alcohols	Esters	Carboxylic acids	Aldehydes
(A)	–OH	–COOH	–COO–	–CHO
(B)	–COO–	–OH	–CHO	–COOH
(C)	–OH	–COO–	–COOH	–CHO
(D)	–CHO	–COO–	–COOH	–OH

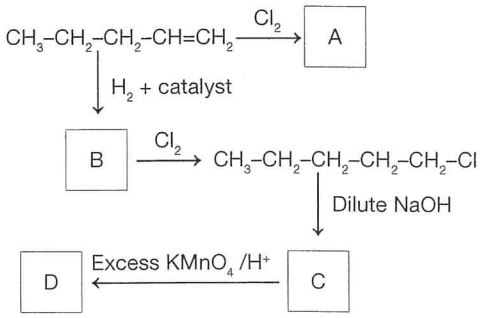
2. The catalyst for the dehydration of ethanol to ethene can be:
   (A) Dilute sulfuric or phosphoric acid.
   (B) The metals platinum or nickel.
   (C) Concentrated sulfuric or phosphoric acid.
   (D) Iron oxide.
3. Which of the following compounds does not react immediately with bromine water, is soluble in water and reacts with a base such as sodium hydroxide?
   (A) $CH_3–CH_2–CH_2–CH_3$
   (B) $CH_3–CH_2–CH_2–COOH$
   (C) $CH_3–CH_2–OH$
   (D) $CH_2=CH–CH_3$
4. The formula of glycerol is:
   (A) $CH_3–CHOH–CH_3$
   (B) $CH_2OH–CH_2OH$
   (C) $CH_3–CH_2–CH_2OH$
   (D) $CH_2OH–CHOH–CH_2OH$
5. Proteins are composed of chains of amino acids joined together by:
   (A) Peptide bonds between the α-amino group and the α-carboxyl group.
   (B) Amide bonds between the α-amino group and the side chain group.
   (C) Strong hydrogen bonds between amino acids.
   (D) Covalent bonds between carboxyl groups.
6. An organic compound liberates CO_2 when reacted with K_2CO_3 and forms propyl ethanoate when reacted with propanol, in the presence of concentrated sulfuric acid. This compound is:
   (A) Propanoic acid.
   (B) Ethanol.
   (C) Propanal.
   (D) Ethanoic acid.
7. 1-Propanol reacts with sodium metal. The gas liberated is:
   (A) CO_2 (B) H_2O (C) O_2 (D) H_2
8. The systematic name for the compound with formula $CH_3–CCl=CBr–CH_3$ is:
   (A) 2-Bromo-3-chloro-but-2-ene.
   (B) 2-Bromo-3-chloro-but-3-ene.
   (C) 3-Bromo-3-chloro-but-2-ene.
   (D) 2-Chloro-3-bromo-but-2-ene.
9. When chlorine (Cl_2) is reacted with propene, the product(s) is/are:
   (A) 1-Chloropropane and HCl.
   (B) 2-Chloropropane only.
   (C) 1,2-Dichloropropane only.
   (D) 1,2-Dichloropropane and H_2.
10. The correct equation for the formation of propanone from an alcohol is:
    (A) $CH_3–CHOH–CH_3 \xrightarrow{KMnO_4/H^+} CH_3–CO–CH_3$
    (B) $CH_3–CH_2–CH_2OH \xrightarrow{KMnO_4/H^+} CH_3–CH_2–CHO$
    (C) $CH_3–CH_2=CH_2 + H_2O \xrightarrow{KMnO_4/H^+} CH_3–CHOH–CH_3$
    (D) $CH_3–CH=CH_2 + H_2O \xrightarrow{KMnO_4/H^+} CH_3–CO–CH_3$
11. The cleaning action of soaps is due to:
    (A) The polar end group binding to the grease.
    (B) Dispersion forces between the grease and hydrocarbon chain and hydrogen bonding with the cation.
    (C) Polar groups binding to water and non-polar groups binding to grease.
    (D) Non-polar groups reducing the surface tension of water.
12. Which alternative contains only addition polymers?
    (A) PET, HDPE, proteins.
    (B) PLA, cellulose, PVC.
    (C) Nylon, polystyrene, LDPE.
    (D) PVC, polystyrene, polyethylene.
13. An example of an unsaturated hydrocarbon is:
    (A) Propane.
    (B) Propene.
    (C) Propanol.
    (D) Cyclohexane.
14. Initiation, propagation and termination are three stages in the production of:
    (A) Ethanol.
    (B) Biodiesel.
    (C) Ethene.
    (D) Polyethene.
15. Starch and glucose are both:
    (A) Addition polymers of glucose.
    (B) Condensation polymers of glucose.
    (C) Addition polymers of glycerol.
    (D) Condensation polymers of glycerol.

16. The reaction involving the conversion of an aldehyde to a carboxylic acid is an example of:
    (A) Reduction.
    (B) Hydrolysis.
    (C) Oxidation.
    (D) Polymerisation.
17. Which list contains chemicals derived from only renewable resources?
    (A) Biodiesel, polylactic acid, ethanol.
    (B) Vegetable oil, diesel, polyethylene.
    (C) Ethanol, natural gas, petrol.
    (D) PLA, PHA, PE.
18. Biodiesel burns with the formation of less pollution than diesel. One explanation for this is:
    (A) Biodiesel is purified during manufacture so that it does not contain contaminants.
    (B) Biodiesel molecules contain oxygen so they burn more completely than diesel.
    (C) Less energy is used in the manufacture of biodiesel.
    (D) Biodiesel is a pure compound not a mixture whereas diesel is a mixture of hydrocarbons.
19. Carboxylic acids are classified as weak acids because they:
    (A) Are found in living things and are non-toxic.
    (B) Are always found in aqueous solution.
    (C) Only partially ionise in solution.
    (D) Release protons easily.
20. Identify the homologous series with the general formula R–NH_2.
    (A) Amides.
    (B) Amino acids.
    (C) Amines.
    (D) Nitrogen alkanes.

Section B – Written Response (55 marks)

21. (3 marks)
    (a) (2 marks)
    Fuels such as biodiesel, ethanol and hydrogen can be synthesised industrially. For one of these fuels, outline a synthesis pathway from organic sources.
    (b) (1 mark)
    The Biofuels Association of Australia website records the demand for diesel in Australia in 2014 as 22.9×10^9 litres. For every litre combusted in an engine, 2.7 kg of carbon dioxide is emitted. If the use of biodiesel reduces the emissions of carbon dioxide by 95%, how many tonnes of carbon dioxide could be saved by replacing 20% of diesel with biodiesel?

22. (8 marks)
    (a) (5 marks)
    Using a named polymer as an example, explain how the conditions under which a synthesis reaction is carried out, such as temperature, pressure and the use of a catalyst, can affect the product(s) made.
    (b) (3 marks)
    Relate the strength, density and biodegradability of starch and cellulose to their structure.
23. (4 marks)
    For the following reaction pathway, provide the name and formula for the substances produced at A, B, C and D.



24. (9 marks)
    An ester was produced by reacting excess ethanoic acid with 10 mL of 1-butanol. The density of ethanoic acid is 1.044 g/mL and the density of 1-butanol is 0.806 g/mL.
    (a) (1 mark)
    Write an equation for this reaction.
    (b) (2 marks)
    Draw and label the apparatus that would be needed for this reaction.
    (c) (2 marks)
    Explain why refluxing is needed for this reaction.
    (d) (3 marks)
    What is the maximum mass of ester that can be produced?
    (e) (1 mark)
    Explain why excess acid was added for this reaction.
25. (9 marks)
    In an experiment in their laboratory, some students decided to make ethanol by fermentation.
    - They dissolved 10 g of glucose in boiled water in a sterile flask and made the volume up to 100 mL.
    - 5 g of yeast was added to provide the enzymes for fermentation.
    - The flask plus contents was weighed.
    - Then the flask was left open in a warm place for several days. During this time, they monitored any mass changes as carbon dioxide gas was lost from the flask.
    - The flask plus contents was reweighed.

(a) (2 marks)
Write a balanced equation for this reaction.

(b) (3 marks)
Calculate the theoretical mass of ethanol and mass of carbon dioxide produced.

(c) (3 marks)
The change in mass of the flask and contents over the time of the experiment was found to be only 1.08 g. Calculate the percentage yield of ethanol.

26. (8 marks)
Each protein has a unique 3-dimensional structure that determines its properties and hence its function.

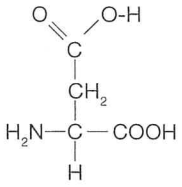
(a) (3 marks)
Distinguish between the primary, secondary and tertiary structure of proteins.

(b) (1 mark)
Why is the 3-dimensional structure unique in every protein?

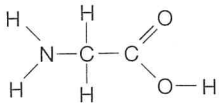
(c) (2 marks)
Describe the bonding that forms the helical structures in proteins.

(d) (2 marks)
The formulas of the amino acids aspartic acid and glycine are shown.

Aspartic acid



Glycine



Draw the dipeptide formed from these two amino acids.

27. (8 marks)
Describe examples of the management and monitoring that would be needed at a chemical plant to ensure:

(a) Worker safety.
(b) Product quality.
(c) Cost effectiveness.
(d) Environmental protection.

28. (3 marks)
Three liquids, each with five carbon atoms in its structure, have boiling points as shown in the table.

	Liquid A	Liquid B	Liquid C
Boiling points (°C)	186	36	116

(a) (1 mark)
If the three liquids are an alkane, a carboxylic acid and an alcohol, name A, B and C.

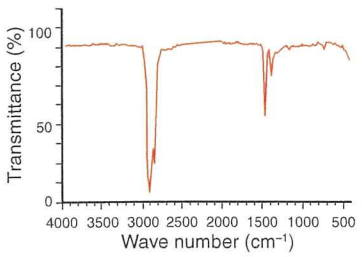
(b) (2 marks)
Explain your reasoning.

29. (4 marks)
The table shows infra-red radiation which is absorbed by some bonds. You should use this information to help answer Question 29.
IR radiation absorbed by specific bonds.

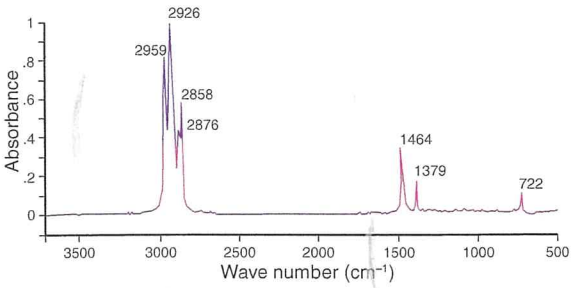
Bond	Wave number absorbed (cm^{-1})
C–O	1050 to 1411
C–H	2850 to 3000 (in alkanes) 3000 to 3100 (in alkenes)
C=O	1700 to 1750
O–H	2500 to 3300 (in carboxylic acids) 3200 to 3600 (in alcohols and phenols)

Four infra-red spectra are shown for three different compounds, an alcohol, a ketone and an alkane. P and Q are spectra of the same compound.

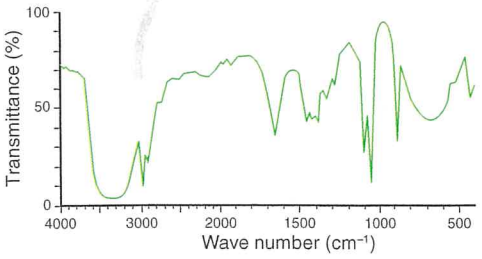
P



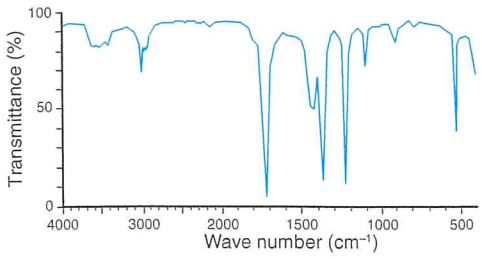
Q



R



S



(a) (1 mark)
With reference to the vertical axis, explain the difference between P and Q.

(b) (3 marks)
Given the data in the table, identify the series that each graph represents. Justify your decision.

85. Thermoplastic.
86. Biopolymers.
87. Repeating unit.
88. Strength of the field, mass of the ion, charge on the ion.
89. Isotopes.
90. Isotopes, structure.
91. Frequency.
92. X-ray crystallography.
93. Spectroscopy.
94. Wavelength.
95. Data bank.
96. Vibrate, stretch and bend.
97. More.
98. Bend.
99. Bonds.
100. Various, e.g. Determine blood alcohol levels, monitor the concentration of carbon dioxide in the blood during surgery, determine the structure of organic molecules.

Chemical Synthesis and Design

1. Various, e.g. design, set up and operate equipment, obtain raw materials, monitor the process, optimise yields, quality control, ensure safety, marketing products.
2. Various, e.g. crushing and grinding, roasting, filtration, fractional distillation, crystallisation, precipitation.
3. Petrochemicals.
4. Synthesis.
5. Body.
6. Various, e.g. to make new products, to improve substances, to test a theory, to confirm chemical structure, to supplement supplies,
7. Various. There are many possible answers, e.g. polymers such as polyvinyl chloride, fertilisers such as ammonium sulfate, proteins, biofuels, cleaning products such as soaps and detergents.
8. Stoichiometric proportions.
9. Surfactants.
10. Emulsifying.
11. Fatty acid, metal.
12. Carboxylic acids, hydrocarbon.
13. Fatty acid.
14. Negative.
15. Sodium stearate.
16. Saponification.
17. Hydrolysis, basic, triglycerides (fats and oils).
18. Glycerol.
19. Vegetable oils.
20. Sodium chloride.
21. Emulsion.
22. Fat in water.
23. Hydroophilic.
24. Hydrophobic.
25. Polar, hydrocarbon chain.
26. Non-ionic.
27. Positively, ammonium.
28. Branched, linear, linear.
29. Sodium carbonate.
30. $Na_2CO_3(aq) + CaCl_2(aq)$
31. Haber.
32. Free radical.
33. Organic.
34. Green.
35. Paul Anastas and John Warner.
36. Various, e.g. prevent waste, atom economy, use less hazardous synthesis processes, design safer chemicals, use safer auxiliaries, energy efficiency, use renewable feedstocks, reduce derivatives, use catalysts, design degradable products, use real-time analysis and monitoring, prevent accidents.
37. Addition.
38. Alkenes.
39. Substitution
40. Addition.
41. Condensation.
42. Polyethylene terephthalate.
43. Glycerine/glycerol.
44. Vegetable oils and animal oils and fats.
45. Various, e.g. soybean, rapeseed, corn, sunflower.
46. Various, e.g. biorenewable, biodegradable, non-toxic, carbon neutral, fewer emissions when burned.
47. $C_2H_4(g) + H_2O(l) \rightleftharpoons C_2H_5OH(l)$
48. Phosphoric or sulfuric acid.
49. Plant sugars, starches and cellulose, e.g. from corn, wheat and sugar cane.
50. Various, e.g. USA (largest producer) also Brazil, Australia.
51. Various.
    (a) Methane in natural gas: $CH_4(g) + H_2O(g) \rightarrow CO(g) + 3H_2(g)$
    (b) Heating oil: $C_{12}H_{24} + 6O_2 \rightarrow 12CO + 12H_2$
    (c) Heating coal: $C_{24}H_{12} + 12O_2 \rightarrow 24CO + 6H_2$
52. Anode, oxidised.
53. Reduced, water, cathode.
54. Hydrogen ions/protons.
55. Molecular manufacturing.
56. Nanotubes.
57. Various e,g, coated with a biocompatible polymer they are used as electrodes in the brain; making fabrics, cars and planes stronger.
58. Nanorobots.
59. Solid-phase synthesis.
60. Initiation, propagation and termination.

Topic Test

Section A – Multiple Choice (20 marks)

1. C	2. C	3. B	4. D	5. A
6. D	7. D	8. A	9. C	10. A
11. C	12. D	13. B	14. D	15. B
16. C	17. A	18. B	19. C	20. C

Section B – Written Response (55 marks)

21. (a) (2 marks)

Marking criteria	Marks
Correctly outlines an industrial synthesis including feedstock and reaction(s)	2
Identifies an industrial synthesis	1

Sample answer:
Various, e.g. Ethanol is fermented under anaerobic conditions from starch, cellulose or sugars using yeast enzymes. The wastes from sugar cane or starch from wheat or corn are commonly used. The ethanol is separated from the ferment by either membrane filtration or distillation.

(b) (1 mark)

Marking criteria	Marks
Correct calculation	1

Sample answer:
Emissions of CO_2 from diesel in 2014 = $2.7 \times 22.9 \times 10^9$ kg
= 61.83×10^9 kg
Emissions of CO_2 by 20% of the fuel = 20% of 61.83×10^9
= 12.366×10^9 kg
CO_2 saved by use of biodiesel = 95% $\times$ 12.366×10^9 kg
= 11.7×10^9 kg = 11.7×10^6 tonnes

22. (a) (5 marks)

Marking criteria	Marks
Explains conditions for synthesis of two forms of a named polymer and relates the conditions to the properties of the polymer	4 to 5
Outlines conditions and properties with an attempt to relate them	2 to 3
Identifies a suitable polymer	1

Sample answer:
Polyethylene is a polymer available in different forms with different properties suitable for different uses.
Low density polyethylene (LDPE) is produced at high temperatures and pressures resulting in a product with considerable chain branching. Thus the polymer chains cannot pack close together and a low density, soft, lightweight and flexible plastic forms.
However, the process of polymerisation which takes place at much lower temperatures and pressures using a Ziegler-Natta catalyst produces high density polyethylene (HDPE) with unbranched chains which pack closely together, a polymer which is harder, stronger, more dense and inflexible.

(b) (3 marks)

Marking criteria	Marks
Outlines the structure of both polymers and relates to all three properties	3
Outlines the structure of both polymers and relates to one or two properties	2
Outlines the structure of both polymers or relates structure to properties for one polymer	1

Sample answer:
Both starch and cellulose are polymers of glucose, however, starch has α-glucose units and chain branching which does not allow the chains to pack closely together. Cellulose monomers are β-glucose units which produce a linear chain with no branching. Hence the chains pack closely and parallel with strong hydrogen bonding between the chains. This produces a strong, fibrous and denser polymer, insoluble in water. Starch is softer, soluble and less dense. Starch is readily attacked by digestive enzymes of animals whereas cellulose can only be biodegraded by a few organisms due to its fibrous nature and insoluble properties.

23. (4 marks)

Marking criteria	Marks
Correct formula and names for all four chemicals	4
Three correct	3
Two correct	2
One correct	1

Sample answer:
A. 1,2-Dichloropentane. $CH_3–CH_2–CH_2–CHCl–CH_2Cl$
B. Pentane. $CH_3–CH_2–CH_2–CH_2–CH_3$
C. Pentan-1-ol or 1-pentanol. $CH_3–CH_2–CH_2–CH_2–CH_2OH$
D. Pentanoic acid. $CH_3–CH_2–CH_2–CH_2–COOH$

24. (a) (1 mark)

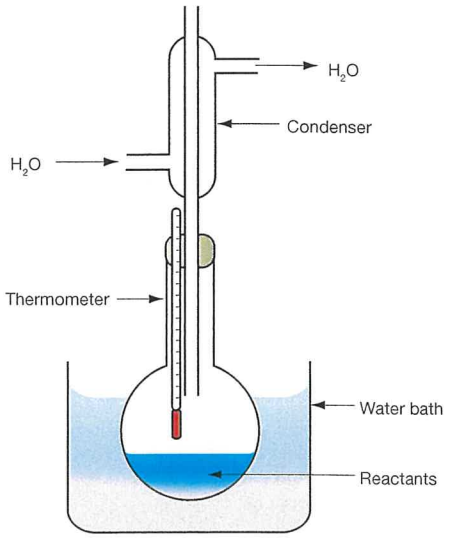
Marking criteria	Marks
Correct equation	1

Sample answer:
$CH_3–COOH\ (l) + CH_3–CH_2–CH_2–CH_2OH\ (l) \xrightarrow{\text{conc. } H_2SO_4} CH_3–COO–CH_2–CH_2–CH_2–CH_3\ (l) + H_2O\ (l)$

(b) (2 marks)

Marking criteria	Marks
Correct diagram using pencil and ruler and labelled	2
Correct diagram but no labels	1

Sample answer:



(c) (2 marks)

Marking criteria	Marks
Explain use of refluxing	2
Outline use of refluxing	1

Sample answer:
Refluxing uses a condenser placed vertically above the reaction flask with cold water running through the jacket. This cools and condenses any vapours that come from the flask through the condenser so that they then run back down into the flask. This keeps volatile reactants and products, such as alcohol, in the flask so that the reaction can continue, and prevents flammable and toxic vapours from escaping to the environment.

(d) (3 marks)

Marking criteria	Marks
Correct calculation arriving at correct mass of ester produced	3
Correct calculation of moles of acid and moles of alcohol	2
Correct calculation of moles acid or alcohol	1

Sample answer:
Density of $CH_3–CH_2–CH_2–CH_2OH = \frac{\text{mass}}{\text{volume}} = 0.806$
Mass of $CH_3–CH_2–CH_2–CH_2OH$ = density × volume = 8.06 g
Moles of $CH_3–CH_2–CH_2–CH_2OH = \frac{\text{mass}}{\text{molar mass}} = 0.1087$
According to the equation, 1 mole butanol produces 1 mole ester (stoichiometric ratio is 1 : 1)
So moles ester produced = 0.1087
Mass of ester = moles × molar mass of ester = 12.6 g

(e) (1 mark)

Marking criteria	Marks
Correct explanation	1

Sample answer:
The reaction is an equilibrium reaction. Excess acid shifts reaction to the right, increasing the yield of ester.

25. (a) (2 marks)

Marking criteria	Marks
Correct equation with yeast enzymes included	2
One formula incorrect or yeast enzymes not included	1

$$C_6H_{12}O_6(aq) \xrightarrow{\text{yeast enzymes}} 2CH_3CH_2OH(aq) + 2CO_2(g)$$

(b) (3 marks)

Marking criteria	Marks
Correct calculation of mass of ethanol and of carbon dioxide	3
Correct calculation of moles of ethanol and carbon dioxide produced	2
One mole calculation correct	1

Sample answer:
Moles glucose reacted $= \frac{\text{mass}}{\text{molar mass}} = \frac{10}{180.156} = 0.0555$ mol
In the equation, 1 mol glucose produces 2 mol ethanol
Moles ethanol produced $= 2 \times 0.0555 = 0.1110$ mol
Theoretical mass ethanol produced = moles × molar mass
$= 0.1110 \times 46.068\text{g} = 5.1$ g
Moles CO_2 produced $= 0.1110$
Mass CO_2 produced $= 0.1110 \times 44.01 = 4.885$ g

(c) (3 marks)

Marking criteria	Marks
Correct calculation	3
Moles of ethanol or moles of carbon dioxide	2
Realising that mass lost was due to carbon dioxide escaping	1

Sample answer:
Loss of mass was due to escape of CO_2.
Moles CO_2 lost was $\frac{1.08}{44.01} = 0.0245398$
Moles ethanol actually produced $= 0.0245398$
$\%\text{ yield} = \frac{\text{actual yield}}{\text{theoretical yield}} \times \frac{100}{1} = \left(\frac{0.0245398}{0.1110}\right) \times 100 = 22\%$

26. (a) (3 marks)

Marking criteria	Marks
Correct definition of primary, secondary and tertiary structure to show differences	3
Two correct	2
One correct	1

Sample answer:
Primary structure is the sequence of amino acids in the polypeptide chain whereas secondary structure refers to the areas of the chain folded into helical or pleated sheet structures. Once the primary and secondary structures are in place, the chain folds into its final 3-D shape. This is the tertiary structure.

(b) (1 marks)

Marking criteria	Marks
Outlines how this determines tertiary structure	1

Sample answer:
Each protein has its own unique number and sequence of amino acids. Hence the type and position of the side chain groups is unique. The position of the amino acid side chain groups determines the 3-D folding because the bonding between the side chain groups holds the polypeptide chain in the final 3-D structure.

(c) (2 marks)

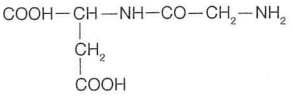
Marking criteria	Marks
Describes the bonding	2
Identifies the bonding	1

Sample answer:
The α-amino and α-carboxyl groups join to form the peptide links in the chain and, when hydrogen bonded, they cause the chain to twist into a helix. The hydrogen bonding occurs between the amino and carboxyl groups in the peptide bonds.

(d) (2 marks)

Marking criteria	Marks
Correct structure	2
Structure partly correct	1

Sample answer:



27. (8 marks)

Marking criteria	Marks
Four parts described fully	7 to 8
Three sections fully described or four partially described	5 to 6
Two sections fully described or three partially described	3 to 4
One section fully described or two partially done	1 to 2

Sample answer:

(a) Workers need to be thoroughly trained, plant must be secure and all necessary safety equipment supplied and used including the ready availability of showers in case of accidental exposure to chemicals. Appropriate clothing to be worn at all times such as hard hats, breathing apparatus, and badges to monitor radiation exposure.

(b) Raw materials need to be tested for quality and purity before use. Effective separation techniques need to be used and product must be tested for composition, purity and possible contamination. In the case of the production of pharmaceutical products, it is essential to ensure that the correct amount of an active ingredient is present.

(c) The percentage yield affects the profit, so the design of the plant, the efficiency of the process and of energy use need to be constantly monitored. Reactants should be used in stoichiometric proportions to minimise waste. Regular maintenance and a well trained workforce contribute to efficiency. Also, finding markets for any by-products will increase profits.

(d) There must be constant testing of water, air and surrounding soil for any contamination. All wastes must be treated appropriately before disposal and stored in a way that ensures they cannot escape into the environment. After the plant is decommissioned, the area should be restored.

28. (a) (1 mark)

Marking criteria	Marks
Correct identification	1

Sample answer:
A – pentanoic acid; B – pentane; C – pentanol.

(b) (2 marks)

Marking criteria	Marks
Describes the bonding and relates to boiling point	2
Identifies the bonding	1

Sample answer:
Boiling point depends on the strength of intermolecular bonding between molecules; the stronger the bond the higher the boiling point.
Pentanoic acid has the strongest hydrogen bonding and hence the highest boiling point. Pentanol also has hydrogen bonding, but there are fewer bonds and hence the boiling point is not as high. Pentane has only weak dispersion forces between its molecules, so it has the lowest boiling point.

29. (a) (1 mark)

Marking criteria	Marks
Correct explanation	1

Sample answer:
P has transmission as a vertical axis which is the amount of radiation that has passed through the sample, expressed as a percentage of the radiation initially entering the sample. Hence there is a decrease in transmission as energy is taken up by a bond.
Q has absorbance for the vertical axis. This is a measure of the amount of energy absorbed at each wave number. Hence there is an increase at each wavelength where energy is taken into a bond.
$[A = \log 10 \frac{1}{T}]$

(b) (3 marks)

Marking criteria	Mark
Three graphs explained	3
Two graphs explained	2
One graph explained	1

Sample answer:
P and Q are the spectra of the alkane as there is a peak at just under 3000 cm^{-1} due to the vibrations of the C–H bonds. There is no significant peak at either the O–H or C=O wave numbers. R is the alcohol as it has a broad peak between 3200 and 3500 cm^{-1}. This indicates presence of the the O–H group. S is therefore the ketone. This is confirmed by the peak at 1700, indicating the C=O group.