TRIAL TEST 5: CHEMICAL SYNTHESIS

Time allowed:	70 minutes	Section 1 – Multiple Choice	20 marks
Total marks:	80	Section 2 – Short & Extended Answer	60 marks

SECTION 1 – MULTIPLE CHOICE (20 MARKS)

1. Which of the following compounds would be best to mix with warm water to help remove cooking oil from a fry pan?
   (a) C_7H_{16}
   (b) CH_3CHO
   (c) CH_3COOCH_3
   (d) $C_{16}H_{33}COONa$

2. The cleansing action of soaps is decreased when water contains which of the following ions:
   I. Na^+ ions
   II. Ca^{2+} ions
   III. NO^{3-} ions
   IV. Mg^{2+} ions
   (a) I only
   (b) II only
   (c) II, III and IV
   (d) II and IV

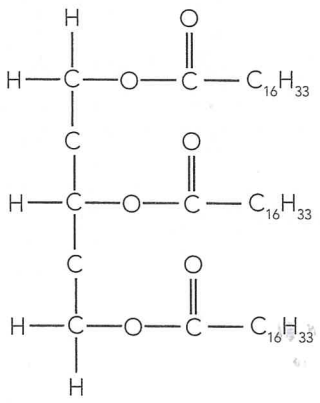
3. Which of the following statements about soaps is true?
   (a) Soaps dissolve oils by forming hydrogen bonds with the hydrophilic section of the oil
   (b) Soaps are unable to lather in hard water as scum forms when the stearate ion forms a polymerised precipitate with divalent anions in the water.
   (c) Soaps dissolving oils involves the alkyl region of soap ions being attracted to and then surround small globules of oil molecules.
   (d) Soaps are sulfonated esters of long chain fatty acids.

4. Which of the following statements about the production of alcohol by fermentation is **not** true?
   (a) Fermentation involves biological catalysts aiding the breakdown of the starch polymer into its monomer units.
   (b) Carbon dioxide is formed when the enzymes in yeast catalyse the breakdown of glucose.
   (c) To be pure enough for use as a biofuel, the yeast and starch must be distilled.
   (d) The alcohol to be used is purified by passing it through a molecular sieve.

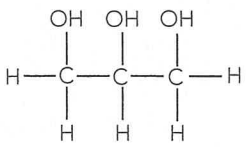
5. For use as a supplement to petrol, alcohol can be produced by fermentation or by:
   (a) The reduction of ethanoic acid obtained from the oxidation of grape vinegar.
   (b) The hydrolysis of ethene obtained from the cracking of hydrocarbons produced in the petroleum industry.
   (c) The bi-product of the base catalysed esterification of triglycerides.
   (d) The de-poylermisation of polyethene.

6. Which of the following molecules would be suitable for use as a biofuel?

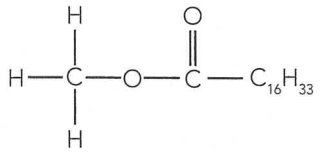
(a)



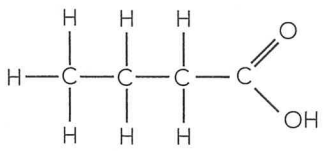
(b)



(c)



(d)



Questions 7 and 8 refer to the following stages in the production of sulfuric acid:

$S_{(s)} + O_{2(g)} \rightarrow SO_{2(g)} + 297 \text{ kJ mol}^{-1}$

$2SO_{2(g)} + O_{2(g)} \rightleftharpoons 2\ SO_{3(g)} + 198 \text{ kJ mol}^{-1}$

$SO_{3(g)} + H_2SO_{4(l)} \rightarrow H_2S_2O_{7(l)}$

$H_2S_2O_{7(l)} + H_2O_{(l)} \rightarrow 2\ H_2SO_{4(l)}$

7. Which of the following statements is most correct?
   (a) The production of sulfur trioxide is carried out at the moderately high temperature of 450°C due to reaction rate considerations rather than yield considerations.
   (b) The equilibrium yield of sulfur trioxide is favoured by a high pressure in the reaction vessel however the cost of building high-pressure reaction vessels means that a high temperature is used instead.
   (c) Sulfur trioxide is dissolved in sulfuric acid rather than water because the product $H_2S_2O_7$ is much more soluble in water and consequently this additional step increases the yield of sulfuric acid.
   (d) The burning of the sulfur to produce sulfur dioxide must be carried out at a low temperature to ensure that the sulfur is not liquefied before combustion as liquid sulfur will inhibit the action of the vanadium catalyst.

8. When 32 g of sulfur is burnt in 32 g of oxygen
   (a) 196 g of sulfuric is produced
   (b) 64 g of sulfur dioxide is produced
   (c) 80 g of sulfur trioxide would be produced
   (d) 32 g of water is consumed to produce the sulfuric acid.

9. A 25.0 g sample of lead ore, predominantly PbS, was reduced to pure lead by the following process:

$2\ PbS + 3\ O_2 \rightarrow 2\ PbO + 2\ SO_2$

$2\ PbO + C \rightarrow 2\ Pb + CO_2$

If the lead ore was 63.5% PbS the mass of pure lead that could be obtained from the

25.0 g sample is:

(a) 15.9 g
(b) 6.74 g
(c) 13.7 g
(d) 27.4 g

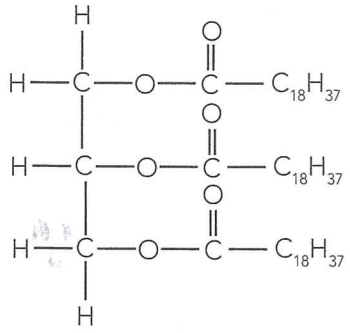
10. What mass of ammonia could be collected when 14.7 g of ammonium chloride mixed with 24.5 g of calcium hydroxide and heated?

$2\ NH_4Cl + Ca(OH)_2 \rightarrow CaCl_2 + 2\ NH_3 + 2\ H_2O$

(a) 14.7 g
(b) 5.6 g
(c) 11.2 g
(d) 4.7 g

SECTION 2 – SHORT AND EXTENDED ANSWER (60 MARKS)

11. A soap is to be made from a fat with the formula as shown below:



(a) Write the equation for the reaction of this tristearate with NaOH to form soap.

[4 marks]

(b) With the aid of a diagram explain how soap can clean a dirty plate.

[4 marks]

(c) Briefly explain why a sample of water would be classified as hard, include the names of chemical species causing this.

[2 marks]

(d) Draw the structure of a typical detergent and explain what advantages detergents have over soaps.

[4 marks]

12. Two biofuels that are used around the world are ethanol, as an additive to petrol, and biodiesel as a replacement for "standard" diesel.

(a) Write the equation for the production of ethanol from ethene.

[3 marks]

(b) Write an equation for the production of a biodiesel from a fat or oil (tristearate).

[3 marks]

(c) What is the most common source of ethene and "standard" diesel?

[2 marks]

(d) Why are motorists encouraged to use biofuels over "standard" fuels in their motor vehicle?

[2 marks]

(e) Name two types of catalyst that are used in the production of biodiesel.

[2 marks]

13. Ammonia can be produced by the Haber Process.

(a) Write the equation for production of ammonia by this process.

[2 marks]

(b) This process should be carried out at a high pressure. Explain why.

[2 marks]

(c) Predict the effect an increase of temperature would have on the equilibrium yield of ammonia.

[2 marks]

(d) At what temperature is the Haber Process carried out. Justify the use of this temperature.

[3 marks]

(e) What catalyst is used in the Haber process? What effect does it have on the equilibrium yield of ammonia and why is it used?

[3 marks]

14. The North-West Shelf in Western Australia has large reserves of natural gas. The major component of natural gas is methane, which is used, primarily as fuel for heating and the generation of electricity. One possible use of methane is to convert it to methanol that will then be used as a petrol substitute.

The first stage in the conversion of the methane in natural gas to methanol is to remove impurities from the natural gas. These impurities often include ethane, propane, carbon dioxide, sulfur compounds, nitrogen and water.

The second stage in the production of methanol is to react methane with steam

$$CH_{4(g)} + H_2O_{(g)} \rightarrow CO_{(g)} + 3\,H_{2(g)}$$

In the third stage, carbon monoxide and hydrogen are mixed at high temperature and pressure over an iron catalyst.

$$CO_{(g)} + 2\,H_{2(g)} \rightarrow CH_3OH_{(g)}$$

If a 1 tonne sample of natural gas was 85.0% methane, calculate:

(a) The mass of hydrogen gas that could be produced from this sample.

[4 marks]

(b) The mass of methanol that could be recovered from the 1 tonne sample if the reaction process was 92.5% efficient.

[6 marks]

15. Sea water contains approximately 0.13% magnesium by mass. The magnesium can be extracted from the sea water by the following steps:

A: Mg^{2+} ions are removed from the sea water by precipitation:

$$Mg^{2+}(aq) + Ca(OH)_2(s) \rightarrow Mg(OH)_2(s) + Ca^{2+}(aq)$$

B: The magnesium precipitate is then converted to a magnesium chloride solution by the addition of hydrochloric acid.

$$Mg(OH)_2(s) + 2\ H^+(aq) + 2\ Cl^-(aq) \rightarrow Mg^{2+}(aq) + 2\ Cl^-(aq) + 2\ H_2O(l)$$

C: The magnesium chloride is crystallised from solution and heated to form magnesium oxide

$$MgCl_2.6H_2O(s) \rightarrow MgO(s) + 2\ HCl(g) + 5\ H_2O(g)$$

D: Molten magnesium oxide is electrolysed to form pure Mg

Anode: $Mg^{2+}(l) + 2\ e^- \rightarrow Mg(l)$
Cathode: $2\ Cl^- \rightarrow Cl_2(g) + 2\ e^-$

(a) To initiate the extraction process, 1480 kg of calcium hydroxide was added to excess sea water. After a full cycle of the extraction process, 1120 kg of chlorine gas was collected at the cathode. Calculate the efficiency of the extraction process.

(b) Given this level of efficiency calculate the mass of sea water required per kilogram of magnesium produced.

[12 marks]

END OF TEST – TOTAL 80 MARKS

TRIAL TEST 5:
Chemical Synthesis

Section 1

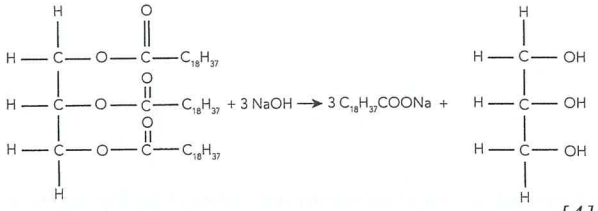
1. *d*	6. *c*
2. *d*	7. *a*
3. *c*	8. *b*
4. *c*	9. *c*
5. *b*	10. *d*

[20]

Section 2

11.

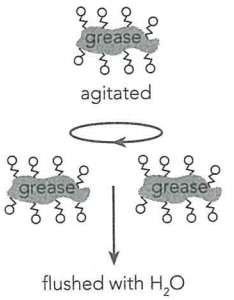
(a)



[4]

(b)

o = hydrophillic end
ϟ = hydrophobic (non-polar) end

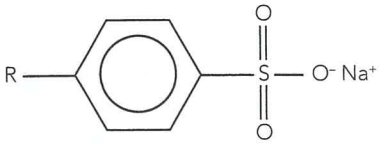


[4]

(c) Water is classified as hard if soap will not lather in it. This is caused by the water containing Mg^{2+} and Ca^{2+} ions that form insoluble salts with soap anions.

[2]

(d)

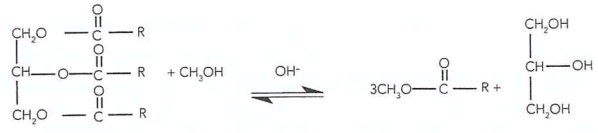


[4]

12.

(a) $C_2H_4 + H_2O \rightarrow CH_3CH_2OH$ *[3]*

(b)



[3]

(c) The most common source of ethene and diesel is from crude oil. *[2]*

(d) Standard fuels are fossil fuels and so are not renewable. Biofuels are from renewable sources and the use of them will prolong the life of the fossil fuels.

[2]

(e) lipase and bases (such as sodium hydroxide).

[2]

13.

(a) $3\ N_{2(g)} + 2\ H_{2(g)} \rightarrow 2\ NH_{3(g)} + 92\ kJ\ mol^{-1}$

[2]

(b) At high pressure the concentration of all gaseous species is increased. The forward reaction is favoured as it reduces the number of particles and consequently partially counteracts the imposed pressure increase. The forward reaction being favoured leads to a higher yield of NH_3.

[2]

(c) As the forward reaction is exothermic, an increase in temperature will lead to the reverse reaction being favoured to partially counteract the imposed change. This would lead to a lower yield of ammonia.

[2]

(d) The Haber process is carried out at approximately 500 °C. This high temperture is required to ensure that the reaction rate is suffiently high to produce ammonia at a rte that is economically viable.

[3]

(e) An iron/iron oxide catalyst is used to increase the rate of production of ammonia. As it effects the forward and reverse reactions equally, a catalyst has no effect on the equilibrium yield of ammonia.

[3]

14.

(a) m(methane) = 850 000 g

$$n(CH_4) = \frac{n}{M} = \frac{850000}{16.042} = 5.299 \times 10^4$$

$n(H_2) = 3.n(CH_4) = 1.59 \times 10^5$
$m(H_2) = n.M = 1.59 \times 10^5 \times 2.016 = 3.20 \times 10^5\ g$
$m(H2) = 320\ kg$

[4]

(b) $n(CH_3OH) = n(CH_4) = 5.299 \times 10^4$
$m(CH_3OH)$ *if 100% efficient* $= n.M$
$m(CH_3OH) = 5.299 \times 10^4 \times (12.01 + 3.024 + 16.00 + 1.008)$
$m(CH_3OH) = 1.698 \times 10^6\ g$

m(CH_3OH) at 92.5% efficiency

$$= 1.698 \times 10^6 \times \frac{92.5}{100}$$

m(CH_3OH) = 1.57×10^6 g (1.57 tonne)

[6]

15.

(a) By examining the reaction pathways, 1 mole of $Ca(OH)_2$ will lead to 1 mole of Cl_2 being produced.

$$n(Ca(OH)_2) = \frac{m}{M} = \frac{1480000}{(40.08 + 32.00 + 2.016)} = 19974$$

$$n(Cl_2) = \frac{m}{M} = \frac{1120000}{70.90} = 15796$$

If 100% efficient. 19974 mol of $Ca(OH)_2$ should produce 19974 mol of Cl_2.

Efficiency of process

$$= \frac{(n(Cl_2)}{n(Ca(OH)_2) \times \frac{100}{1}}$$

$$= (\frac{15796}{19974}) \times \frac{100}{1}$$

$$= 79.1\%$$

(b) If 100% efficient, 1kg of sea water would produce 0.0013 kg of Mg

$$i.e. \frac{1}{0.0013} = \frac{x}{1}$$

x = 7692 kg (7962 kg of sea water required to produce 1 kg of Mg)

However process is on 79.1% efficient, therefore

$$m(sea\ water) = 7692 \times \frac{79.1}{100}$$

m(sea water) = 9725 kg

[12]