Australian Islamic College 2018

ATAR Chemistry Units 3 and 4

Task 12 (Weighting: 3%)

Polymers and Chemical Synthesis Test

Test Time: 45 minutes

Please do not turn this page until instructed to do so.

First Name	Surname
ANSWERS	

Teacher

Mark / 41	Percentage

Equipment allowed: Pens, pencils, erasers, whiteout, rulers and non-programmable calculators permitted by the Schools Curriculum and Standards Authority.

Section 1: Multiple Choice **[10 marks]**

1. Ammonia can be produced according to the following equation

$$N_2 + 3H_2 \rightleftharpoons 2NH_3$$

The reaction as written is exothermic.
Which of the following changes will increase the amount of ammonia at equilibrium?

I adding a finely divided catalyst
I increasing the partial pressure of the gases
II increasing the temperature in the reaction vessel

(a) I only
(b) II only
(c) I and II only
(d) II and III only

Questions 2, 3 and 4 refer to the following information.

Nitric acid, HNO_3, is an important industrial chemical. The synthesis of nitric acid involves the oxidation of nitrogen. However, the direct oxidation of atmospheric nitrogen produces a very small percentage yield. A less direct, but more successful, reaction sequence is outlined below.

I $4NH_3(g) + 5O_2(g) \rightleftharpoons 4NO(g) + 6H_2O(g)$ $\Delta H < 0$

II $2NO(g) + O_2(g) \rightleftharpoons 2NO_2(g)$ $\Delta H < 0$

III $3NO_2(g) + H_2O(l) \rightarrow 2HNO_3(aq) + NO(g)$

2. Reaction I is slow at room temperature. To increase the reaction rate to an acceptable level, a finely divided catalyst is used and the temperature raised to about 900°C. Which one of the following alternatives correctly describes why a catalyst and an increase in temperature increase the reaction rate?

	Catalyst	**Increase in temperature**
(a)	increases the activation energy of the reaction	increases the activation energy of the reaction
(b)	decreases the activation energy of the reaction	decreases the activation energy of the reaction
(c)	increases the average energy of molecules so that a higher proportion collide successfully	increases the energy required for molecules to collide successfully
(d)	decreases the energy required for molecules to collide successfully	increases the average energy of molecules so that a higher proportion collide successfully

3. Which one of the following combinations of temperature and pressure will result in the highest equilibrium yield of $NO_2(g)$ in reaction II?

	Temperature (°C)	**Pressure (kPa)**
(a)	30	100
(b)	30	300
(c)	300	100
(d)	300	300

4. Which one of the following statements about Reaction **III** is correct?

(a) It is a redox reaction and H_2O molecules act as oxidising agents.
(b) It is a redox reaction and H_2O molecules act as reducing agents.
(c) It is a redox reaction and NO_2 molecules act as oxidising agents.
(d) It is a hydrolysis reaction, not a redox reaction.

5. Which of the following combinations of reactants can be used to make a condensation polymer?

(a) $CH_3(CH_2)_4COOH$ and $HOCH_2(CH_2)_4CH_3$
(b) $HOCH_2(CH_2)_4CH_2OH$ and $HOOC(CH_2)_4COOH$
(c) $CH_3(CH_2)_4CH_2OH$ and $HOOC(CH_2)_4COOH$
(d) $CH_2=CH_2$ and $CH_2=CHCl$

6. In which one of the following would the position of the equilibrium **NOT** be affected by a volume change at constant temperature?

(a) $2CO(g) + O_2(g) \rightleftharpoons 2CO_2(g)$
(b) $C_2H_6(g) \rightleftharpoons C_2H_4(g) + H_2(g)$
(c) $N_2O_4(g) \rightleftharpoons 2NO_2(g)$
(d) $CO(g) + H_2O(g) \rightleftharpoons H_2(g) + CO_2(g)$

7. Enzymes are efficient, biological catalysts that can be used on an industrial scale.
In which of the following industrial processes can enzymes be used?

I the production of ethanol
II the production of biodiesel
III the production of synthetic detergents

(a) I only
(b) I and II only
(c) I and III only
(d) I, II and III

8. What maintains the secondary, β-pleated sheet structure of a protein?

a) peptide links between amino acid residues within a polypeptide chain
b) hydrogen bonds between amide and carbonyl functional groups within a polypeptide chain
c) hydrogen bonds between amide and carbonyl functional groups in adjacent polypeptide chains
d) hydrogen bonds between highly polar groups on the side chains of amino acid residues in adjacent polypeptide chains

9. When ethene reacts with steam in the presence of a catalyst, what is the molecular formula of the product formed?

a) C_2H_6
b) C_2H_5O
c) C_2H_6O
d) $C_2H_4O_2$

10. Large quantities of hydrogen gas are produced industrially by the steam reforming of natural gas. The equation for this reaction is as follows.

$CH_{4(g)} + H_2O_{(g)} \rightarrow CO_{(g)} + 3H_{2(g)}$ $\Delta H > 0$

Which of the following changes will increase the amount of $H_2(g)$ at equilibrium?

I increasing temperature

II increasing the pressure

III adding a catalyst

a I only

b II only

c I and II only

d I, II and III

End of Section One

Section 2: Short Answer **[31 marks]**

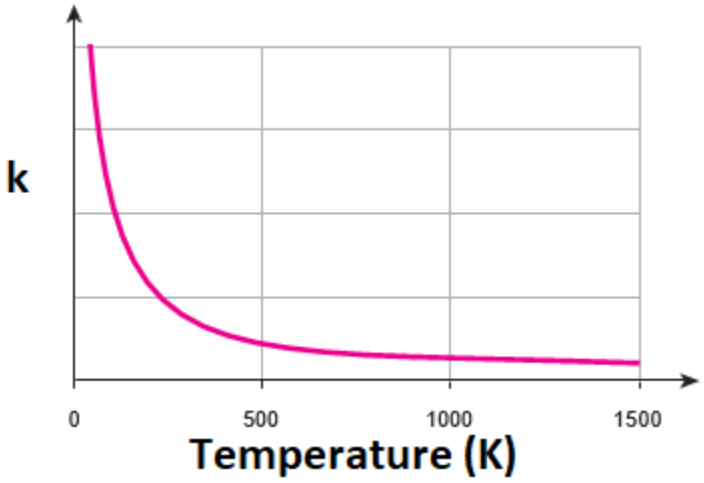
11. Ammonia is one of our most important industrial chemicals. It is produced by the reaction of nitrogen and hydrogen gases according to the following equation.

$N_{2(g)} + 3H_{2(g)} \rightleftharpoons 2NH_{3(g)} \quad \Delta H = -92$ kJ

a **i** Write the equilibrium constant expression for this reaction. (1 mark)

$K = [NH_3]^2/[N_2][H_2]^3$

ii The graph below shows the change in the value of the equilibrium constant as the temperature increases.



Explain the relationship between the value K and temperature in terms of equilibrium principles. (2 marks)

The reaction is exothermic, so an increase in temperature favours the reverse reaction/favours reactants/reduces yield (1). As there is a smaller concentration of reactants and larger concentration of products, the value of K will decrease as the temperature increases (1).

b Industrially, this process is carried out at 350°C to 550°C, at pressures between 100 atm and 250 atm, and with a porous iron oxide catalyst.

i Explain why the process is not carried out at a much higher or much lower temperature. (2 marks)

As the reaction is exothermic, increased yield is favoured by low temperatures but the reaction rate is too slow if the temperature is too low (1). The temperature chosen is a compromise between an acceptable yield and rate (1).

ii Why do elevated pressures increase both the rate of reaction and the yield of ammonia? (4 marks)

At higher pressures, reactants particles are closer together, increasing the likelihood of collisions (1), and so the reaction rate increases (1). As there are 4 moles of reactant molecules but only 2 moles of product molecules (1), an increase in pressures pushes the equilibrium to favour the forward reaction thus increasing the yield of the product (1).

iii Explain why a catalyst increases the reaction rate and the advantage of having a catalyst that is porous. (3 marks)

A catalyst provides a reaction pathway of lower activation energy (1), so a greater proportion of reactant molecules will have energy greater than or equal to the activation energy required to react (1). A porous catalyst provides a large surface area to maximise contact with reactants (1).

b In the industrial production of ammonia, sufficient time is not allowed for the mixture to reach equilibrium. Instead, the gases leaving the converter are cooled. Ammonia is liquefied but not the unreacted nitrogen and hydrogen. These are then recycled into the converter to improve the overall yield of ammonia.

Explain why ammonia liquefies on cooling but nitrogen and hydrogen do not. (1 mark)

Ammonia (unlike hydrogen and nitrogen) forms <u>hydrogen bonds</u> between its molecules, allowing it to liquefy more easily (1).

12. Nylon is a synthetic polymer produced through a condensation polymerisation reaction.

i What is the essential difference between monomers that undergo condensation polymerisation and those that undergo addition polymerisation? (2 marks)

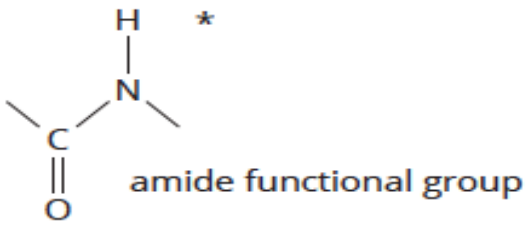
Condensation polymers are formed between monomers that each have two reactive functional groups (1).

Monomers that undergo addition polymerisation each have at least one double bond (1).

ii In terms of intermolecular bonding between chains of nylon, explain why nylon can form very strong fibres. (1 mark)

Relatively strong <u>hydrogen bonds</u> form between the <u>carbonyl oxygens</u> of one chain and the <u>hydrogens bonded to nitrogen atoms</u> on an adjacent chain, thus forming a strong polymer (1).

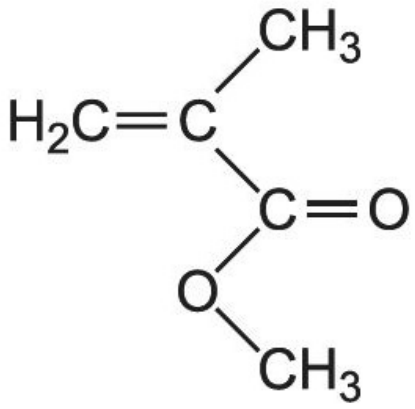
iii Proteins are natural polymers also produced through condensation polymerisation of amino acids. Draw and name the functional group common to both nylon and protein polymers. (2 marks)



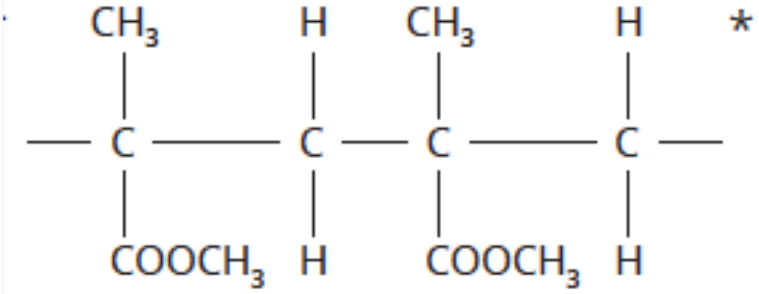
amide functional group

(2)

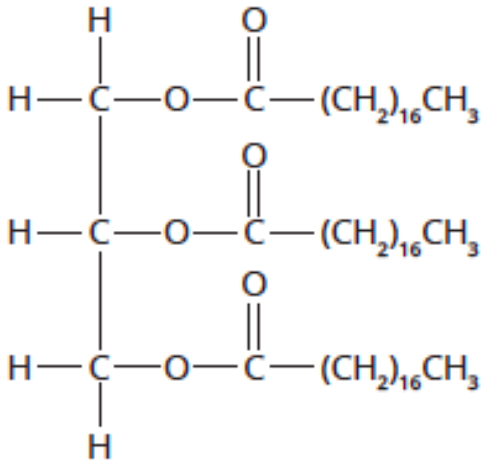
iv The structure of methyl methacrylate is given below.



Methyl methacrylate is the monomer used to produce perspex, a transparent polymer used instead of glass in a number of applications. Deduce whether perspex is formed by addition or condensation polymerisation and draw a section of the polymer showing two monomer units. (2 marks)

Type of polymerisation	**Addition polymerisation**
Section of polymer showing 2 monomer unit	

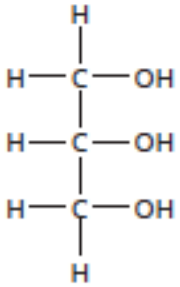
13. The following compound, a triglyceride fat, can be hydrolysed using a base such as sodium hydroxide.



(a) What name is given to the base hydrolysis of fats? (1 mark)

Saponification (1)

(b) Give the structure of the two products of the base hydrolysis of the fat. (2 marks)

Product 1	Product 2
	**$CH_3(CH_2)_{16}COO^+ {}^-Na$**

(c) One of the products above can act as soap.

i. State the structural features of a soap that enable it to act as a grease remover. (1 mark)

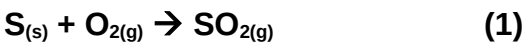
Soaps have a charged / polar / hydrophilic head and a non-polar / hydrophobic (hydrocarbon) tail (1)

i. Explain the cleaning action of soap in terms of the structure of the soap molecule and the types of intermolecular forces involved. (2 marks)

The charged/polar end forms ion–dipole / hydrogen bonds with water molecules (1) and the non-polar end is attracted to grease by dispersion forces (1).

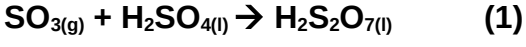
14. The contact process is used to make sulfuric acid.

a. Write, in correct order, balanced equations with state symbols for the four reactions involved in the synthesis of sulfuric acid by the contact process. (4 marks)

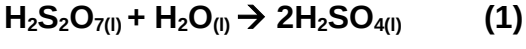


(1)

(1)

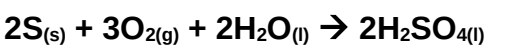


(1)



(1)

b. Add together the four reactions above to produce an overall reaction for the synthesis of sulfuric acid. (1 mark)



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