

**Task 11: Chemical Kinetics and Gases Topic Test**

**MARKING KEY**

**CHEMISTRY UNIT 2**

Student Name: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Teacher’s Name: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

# **TIME ALLOWED FOR THIS PAPER**

Reading time before commencing work: 5 minutes

Working time for the paper: 40 minutes

# **MARKS ALLOWED FOR EACH SECTION**

Section One: Multiple-Choice: 10 marks

Section Two: Short Answer: 15 marks

Section Three: Extended Response: 15 marks

Total: 40 marks

# **MATERIALS REQUIRED/RECOMMENDED FOR THIS PAPER**

**To be provided by the supervisor:**

This Question/Answer Booklet

Chemistry Data Book

**To be provided by the candidate:**

Standard items: pens (blue/black preferred), pencils (including coloured), sharpener, eraser, correction tape/fluid, ruler, highlighters

Special items: up to three non-programmable calculators approved for use in the WACE examinations

# **IMPORTANT NOTE TO CANDIDATES**

No other items may be taken into the examination room. It is **your** responsibility to ensure that you do not have any unauthorised notes or other items of a non-personal nature in the examination room. If you have any unauthorised material with you, hand it to the supervisor **before** reading any further

**Multiple Choice Section10 marks**

1. Which of the following changes would **not** change the initial rate of reaction between zinc and dilute nitric acid?
2. the addition of a catalyst.
3. a change in the temperature of the reactants.
4. using double the volume of the nitric acid
5. breaking down the zinc into smaller pieces
6. Many chemical reactions that are carried out in aqueous solution proceed more slowly if the system is further diluted. This is most likely due to:
7. a change in the nature of the reactants.
8. a change in the surface area of the reactants.
9. a change in the concentration of the reactants.
10. a change in temperature.
11. Potassium permanganate is a purple solution that decolourises when it reacts with excess oxalic acid according to the ionic equation:

2MnO4- (aq) + 5C2H2O4 (aq) + 6H3O+(aq) 🡪 2Mn2+(aq) + 10CO2 (g) + 14H2O(l)

Which of the following is true?

1. When production of carbon dioxide bubbles ceases, there are no reactants left.
2. The faster the bubbles are given off, the slower the rate of reaction.
3. The lighter the colour of the solution, the greater the rate of reaction.
4. The lighter the colour of the solution, the lower the concentration of the reactants.
5. Which of the following statements is **not** correct regarding an ideal gas?
6. The volume of 1 mole of an ideal gas at STP is 22.71 litres.
7. The volume of 1 mole of an ideal gas at absolute zero is 0 litres.
8. The particles of an ideal gas are weakly attracted to one another.
9. The average kinetic energy of ideal gas particles is proportional to temperature.
10. In a particular engine, 3.102 L of propane is allowed to combust completely with oxygen at standard temperature and pressure. What is the volume of carbon dioxide gas produced?

a) 6.204 L  
b) 9.306 L  
c) 3.102 L  
d) 1.551 L

**Short Answer Section15 marks**

**Question 1(3 marks)**

According to Collision theory, what three things are required for a chemical reaction to occur?

1. Particles to collide
2. With sufficient energy
3. And correct orientation

**Question 2(3 marks)**

Catalytic converters are devices that significantly reduce the amount of pollutants released in the exhaust gases of vehicles. Some of the reactions catalysed by the converter are given below:

1. 2 H2(g) + 2 NO(g) → 2 H2O(g) + N2(g) DH = -666 kJ mol-1
2. 2 CO(g) + O2(g) → 2 CO2(g) DH = -566 kJ mol-1
3. CH4(g) + 2 O2(g) → 2 H2O(g) + CO2(g) DH = -803 kJ mol-1

Platinum is the most widely used catalyst, however palladium and rhodium are also very common. Recently, there has been an exploration into the use of nanoparticle catalysts.

1. Give one reason why carbon dioxide gas might be emitted from a catalytic converter, despite being a well-known greenhouse gas.(1 mark)

It is less toxic than carbon monoxide/methane, it is difficult to remove oxygen from carbon, any other reasonable responses

1. Explain, in terms of collision theory, the advantage of using metals in nanoparticle form as opposed to a bulk form.(2 marks)
2. Nanoparticles have a higher surface area, and so more reaction sites
3. This leads to a higher number of collisions and therefore successful reactions, increasing the efficiency of the catalytic converter

**Question 3(6 marks)**

Consider a sample of hydrogen gas housed in a metal container that has a pressure of 1atm and temperature of 500oC. For each of the applied changes, predict the:

* Change in pressure of hydrogen gas
* Change in temperature

You may assume that both pressure and temperature can change at the same time.

|  |  |  |
| --- | --- | --- |
| **Change** | **Change in pressure (increase, decrease, or no change)** | **Change in temperature (increase, decrease, or no change)** |
| More hydrogen gas is injected into the chamber | Increase | Increase |
| Room temperature argon is injected into the chamber | No change | Decrease |
| The gas is allowed to move to a larger container | Decrease | Increase |

**Question 4(3 marks)**

A balloon containing 3.0 L of gas is taken from standard temperature and pressure and placed in a vat of liquid nitrogen. With reference to the kinetic theory of gas, explain what will happen to the size of the balloon assuming no other changes.

1. The liquid nitrogen is at a much lower temperature than the balloon, decreasing the average kinetic energy of the particles inside the balloon
2. This will lead to the particles moving slower, so there is less energy exerted on the walls of the container
3. This will lead to a reduction of the volume of the container so that the pressure is maintained

**Extended Response Section15 marks**

The Haber-Bosch process was developed in the early 20th century by Fritz Haber and Carl Bosch. This reaction converts nitrogen gas and hydrogen gas into ammonia, as shown in the chemical equation below.

N2(g) + 3 H2(g) → 2 NH3(g), ΔH = -92.4 kJ.mol-1

The Haber-Bosch process is conducted at a temperature of approximately 450°C and a pressure of 200 atmospheres.

1. Explain, in terms of collision theory, why using a high temperature increases the rate of reaction.(3 marks)
2. Having a higher temperature means that the particles have a larger amount of average kinetic energy
3. This means the particles are moving around faster, and colliding with more energy
4. As a result, more particles have the required activation energy for a reaction to occur OR there are more collisions, and so more particles will collide with the correct orientation

Much of the groundbreaking work in the Haber-Bosch process focused on the use of catalysts. Iron is the most commonly used catalyst in this process. Typically, the reaction has an activation energy of 110 kJ.mol-1, however the catalyst can reduce this to 50 kJ.mol-1.

1. On the set of axes below, sketch an energy profile diagram for the uncatalysed reaction. Label the enthalpy change and the activation energy.(3 marks)

Progress of reaction

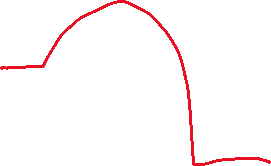
Potential energy (kJ mol-1)

Ea=110kJ/mol

N2 + 3H2



Ea=50kJ/mol



(1) Exothermic shape

(1) Labelled enthalpy with value

(1) Labelled activation energy with value

dH=-110kJ/mol



2NH3



1. On the same set of axes, draw the energy profile diagram for the catalysed reaction using a dotted line.(1 mark)
2. Correct dotted curve – labelled value not required.

The Haber-Bosch process has been instrumental in the production of fertilisers, which has had a significant impact on agriculture. To further increase this impact, recent research has considered the use of enzyme catalysts in the production of ammonia.

1. Describe two ways in which enzymes are different to inorganic catalysts.(2 marks)

Multiple answers, accept any two:

Sensitive to pH, sensitive to temperature, sensitive to their conditions, function via the lock and key model, function via the induced fit model, have a high reaction specificity, are proteins, are biological molecules

Do not accept two reasons that are functionally the same – e.g., “sensitive to pH and sensitive to surroundings”, or, “function via the lock and key model, function via the induced fit model”, or, “are proteins, are biological molecules”.

1. Give one reason why the use of an enzyme would not work under the current conditions of the Haber-Bosch process.(1 mark)

Because they are not able to withstand such high temperatures

The Haber-Bosch process is crucial for the production of ammonia, which is then used to make fertilisers. The chemical equation for the Haber-Bosch process is provided again below, for convenience.

N2(g) + 3 H2(g) → 2 NH3(g), ΔH = -92.4 kJ.mol-1

Assume that a fertiliser plant produces 5000 kg of ammonia each year.

1. Calculate the total volume of nitrogen gas (at STP) that must be collected each year in order to produce this mass of ammonia. State your answer to the appropriate number of significant figures.(5 marks)
2. m(NH3) = 5000 x 103 g
3. n(NH3) = (5000 x 103)/(14.01 + 3 x 1.008) = 293,500 mol
4. n(N2) = ½ n(NH3) = 146,800 mol
5. V(N2) = n(N2) x 22.71 = 3,333,039 L
6. V(N2) = 3,333 kL or 3.333 x 106 L (4 SF)