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GRADE 12 EXAMINATION

JUNE 2022

PHYSICAL SCIENCES: PAPER 2

Time: 2 hours

130 marks

Examiner: K Mari

Moderator: J Morrison-Young

NAME																	
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PLEASE READ THE FOLLOWING INSTRUCTIONS CAREFULLY

1. This question paper consists of 17 pages, and a Data Sheet of 2 pages. Please check that your question paper is complete.
 2. Read the questions carefully.
 3. Answer ALL the questions.
 4. Use the data and formulae whenever necessary.
 5. Show your working in all calculations.
 6. Units need not be included in the working calculations, but appropriate units should be shown in the answer.
 7. Answers must be expressed in decimal format, not left as proper fractions.
 8. Where appropriate, express answers to TWO decimal places.
 9. It is in your own interest to write legibly and to present your work neatly.
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Question 1

Answer these questions on the multiple-choice answer sheet below. Make a cross (X) in the box corresponding to the letter that you consider to be correct.

A	B	☒	D
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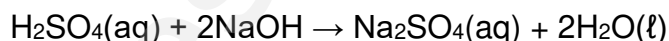
Here the option C has been marked as an example.

1.1	A	B	C	D
1.2	A	B	C	D
1.3	A	B	C	D
1.4	A	B	C	D
1.5	A	B	C	D
1.6	A	B	C	D
1.7	A	B	C	D

1.1 The chemical formula for ammonium phosphate is:

- A) $(\text{NH}_3)_3\text{PO}_3$ B) $(\text{NH}_4)_3\text{PO}_3$
 C) $\text{NH}_4(\text{PO}_4)_3$ D) $(\text{NH}_4)_3\text{PO}_4$

1.2 Study the reaction shown below:



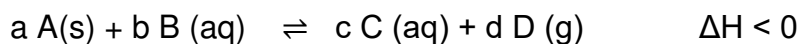
The rate of the reaction, in terms of the number of moles of H_2SO_4 used up, is $2.3 \times 10^{-3} \text{ mol.s}^{-1}$. What is the rate (in mol.s^{-1}) at which H_2O is formed?

- A) 2.3×10^{-3} B) $2.3 \times 10^{-3} \div 2$
 C) $2.3 \times 10^{-3} \times 2$ D) $(2.3 \times 10^{-3} \times 2) \div 60$

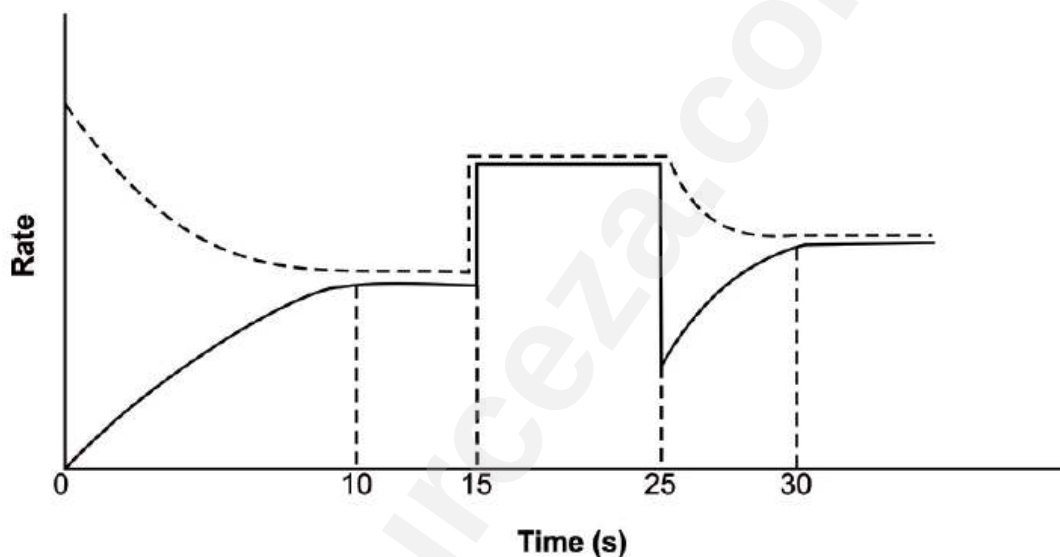
1.3 Hydrohalogenation reactions could involve

- A) the substitution of HBr in an alcohol.
 B) the addition of H_2O to an alkene.
 C) the addition of HCl to an alkene.
 D) the addition of HI to an alcohol.

- 1.4 A hypothetical chemical reaction in a closed container is represented by the following chemical equation.



The graph below represents the rates of the forward and reverse reactions plotted as a function of time.



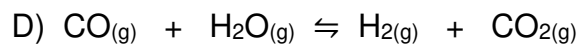
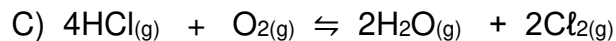
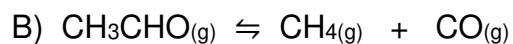
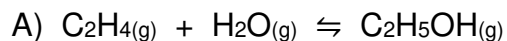
Which one of the following statements could correctly describe the factors that caused the change in reaction rate?

	Disturbance at 15 s	Disturbance at 25 s
A	Surface area of A was increased	The pressure of the system was increased.
B	A catalyst was added.	The temperature was decreased.
C	The temperature of the system was increased.	The surface area of A was decreased.
D	The pressure of the system was decreased.	The temperature of the system was increased.

- 1.5 How many hydrogen atoms are present in 8,5 g of NH_3 ?

- A) $3,01 \times 10^{23}$ B) $6,02 \times 10^{23}$
 C) $9,03 \times 10^{23}$ D) $2,40 \times 10^{24}$

1.6 In which of the following reactions would an increase in pressure have NO EFFECT on the amount of product at equilibrium?



1.7 Which of the following molecules has the highest boiling point?

A) hexane

B) propane

C) 2,3-dimethylbutane

D) propene

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Question 2

2.1 Write down the name of the compound LiMnO_4 . (1)

2.2 Write down the formula for potassium hydrogen carbonate. (1)

2.3 Define *electronegativity*. (2)

2.4 You are provided with a list of substances below. The state labels of each substance is at room temperature. Answer the questions below.

Ni(s) $\text{CS}_2(\text{g})$ C(s) $\text{NH}_3(\text{g})$ $\text{NaNO}_3(\text{s})$ $\text{SiO}_2(\text{s})$ He(g)

Select only one substance from the list above that:
(Each substance may be used once, more than once or not at all.)

2.4.1 is an inert, monatomic substance. (1)

2.4.2 has a high melting point due to strong electrostatic forces between the cations and anions. (1)

2.4.3 has 3 polar covalent bonds and one lone pair of electrons. (1)

2.4.4 has delocalised valence electrons. (1)

2.4.5 has non-polar covalent bonds and has an extremely high melting point due to the giant lattice structure. (1)

2.4.6 has hydrogen bonding intermolecular forces. (1)

2.4.7 can conduct electricity when molten and aqueous only. (1)

2.4.8 has non polar covalent bonds. (1)

2.5 Iodine is a solid at room temperature.

2.5.1 Identify the specific type of intramolecular bond that holds atoms of iodine (I_2) together. (2)

2.5.2 Identify the intermolecular force that holds molecules of iodine together. (1)

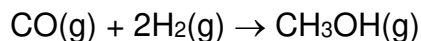
2.5.3 With reference to the intermolecular force identified in **question 2.5.2** above, explain why iodine crystals are solid at room temperature but change from solid to gas when heated gently over a Bunsen burner. (2)

2.5.4 Give one reason why iodine crystals do not conduct electricity. (1)

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Question 3

The reaction below between carbon monoxide and hydrogen can be used industrially to make methanol. The process is carried out at 250°C and between 5000 kPa and 10 000 kPa.

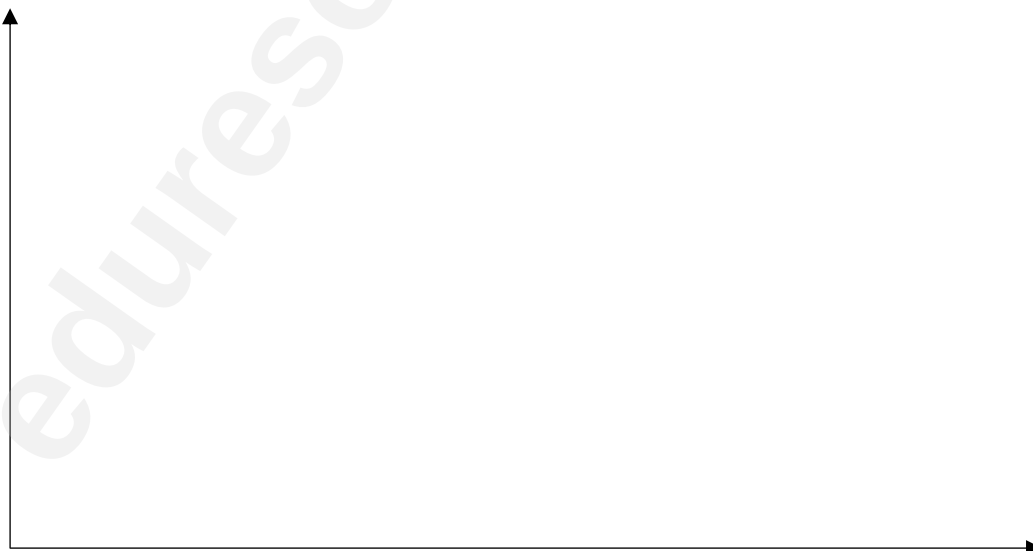


- 3.1 Explain in terms of the collision theory why increasing the pressure increases the yield of methanol. (4)
- 3.2 Define the term *reaction rate*. (2)
- 3.3 The reaction gives a greater equilibrium yield at 100°C than at 250°C. Is the forward reaction in this process exothermic or endothermic? Explain. (3)
- 3.4 Explain why the reaction needs to be carried out at 250°C rather than 100°C. (2)

- 3.5 Draw a reaction rate vs time graph to illustrate the reaction between carbon monoxide and hydrogen from when the reactants were initially placed into the reaction vessel, until equilibrium was reached five minutes later and the catalyst, Al_2O_3 , is added to the system five minute after equilibrium had been reached. (5)



- 3.6 Aluminium oxide is a catalyst in this process. Draw and label an energy profile diagram of E_p versus course of reaction, to clearly show how a catalyst affects the activation energy required for this reaction. (4)



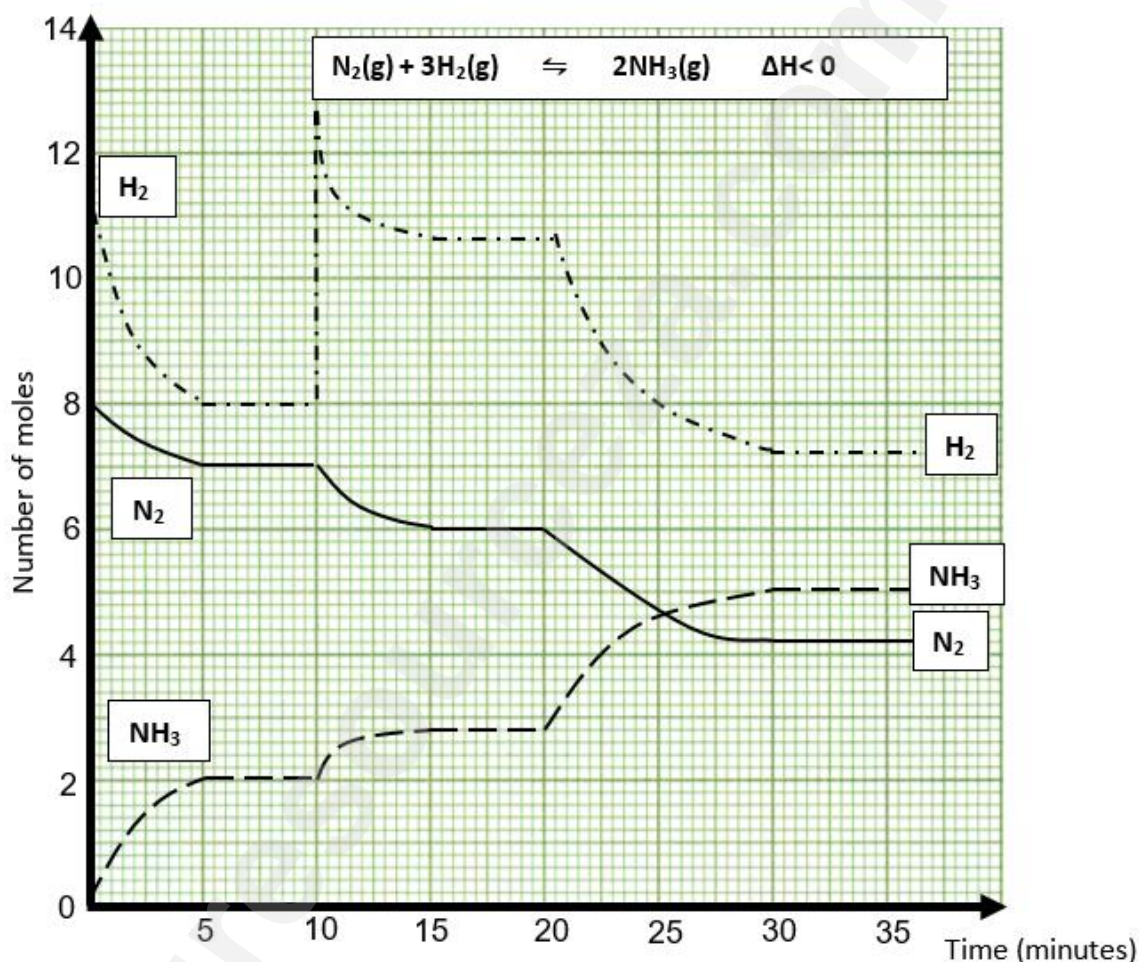
- 3.7 If 100 dm^3 carbon monoxide and 120 dm^3 hydrogen are placed in a container at STP and allowed to react completely, which gas would be in excess and by how many moles? (7)

- 3.8 Calculate the volume of methanol gas that would be produced in **3.7** should the reaction run to completion with the quantities given in **3.7**. (2)

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Question 4

- 4.1 In a Haber Process reaction to make ammonia, 8 mol of N_2 gas and 11 mol of H_2 gas is introduced into a container of volume 10 dm^3 at a temperature of 450°C . The container is sealed immediately after the gases are added. The graph below represents the changes in the number of moles of the gases in the reaction vessel over a period of 35 minutes.



- 4.1.1 Write an equilibrium constant expression, K_c for the Haber Process reaction. (2)
- 4.1.2 Use figures from the graph to determine the equilibrium concentrations of H_2 , N_2 and NH_3 at a time of 8 minutes. (5)

- 4.1.3 Show that the equilibrium constant, K_c at 450°C , for this reaction, at a time of 8 minutes is 0.11. (2)
- 4.1.4 Evaluate the significance of the K_c value at 450°C in terms of whether the reactants or products will be favoured. (3)
- 4.1.5 What change was made to the equilibrium mixture at a time of 10 minutes? (2)
- 4.1.6 State *Le Chatelier's Principle*. (2)
- 4.1.7 Use *Le Chatelier's Principle* to explain why the number of moles of the various gases changed as they did after the change at 10 minutes was made. (3)

4.2 A chemical engineer, Ogodiseng, is investigating the Haber process and so performs an experiment. She places 0.5 mol of N_2 and 2.3 mol of H_2 into a 2 dm^3 container and waits for the equilibrium to be established. She then measures the amount of N_2 present and discovers that there is 0.35 mol at equilibrium.

4.2.1 Using the information given above and the expression for K_c , calculate the value of K_c at the temperature at which Ogodiseng did her experiment. Round off your answer at the end. (7)

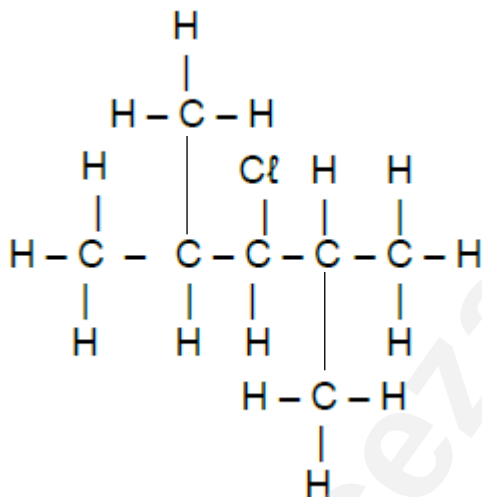
4.2.2 Compare the value calculated in **Question 4.2.1** to that calculated in **Question 4.1.3**. Did Ogodiseng do her experiment at a temperature above or below 450°C ? (2)

4.2.3 Explain your answer to **Question 4.2.2**. (4)

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Question 5

5.1 Give the IUPAC name of the compound drawn below. (4)



5.2 Define the term *unsaturated compound*. (2)

5.3 Consider the organic compound 2-bromobutane-2,3-diol.

5.3.1 Draw the full structural formula for 2-bromobutane-2,3-diol. (4)

5.3.2 Is 2-bromobutane-2,3-diol UNSATURATED or SATURATED? (1)

5.4 2-fluorobutane reacts with a hot concentrated solution of NaOH in an ethanol solvent to produce but-2-ene.

5.4.1 Name the GENERAL type of reaction described above. (1)

5.4.2 Use condensed-structural formulae to write a balanced chemical equation for the reaction. (3)

5.4.3 Describe a chemical test that can be used to confirm the product is an alkene. (3)

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Question 6

Emilia reacts butan-1-ol with propanoic acid to produce an ester.

- 6.1 NAME the catalyst required for this reaction to occur. (1)
- 6.2 Define the term *homologous series*. (2)
- 6.3 Name the homologous series to which propanoic acid belongs. (1)
- 6.4 NAME the functional group present in butan-1-ol. (1)
- 6.5 Draw the structural formula of the ester formed in this reaction. (4)
- 6.6 Give the IUPAC name of a positional isomer of the ester drawn in **Question 6.5**. (2)

- 6.7 Use molecular formulae to write a balanced chemical equation for the combustion of butan-1-ol ($\text{C}_4\text{H}_{10}\text{O}$). (3)
- 6.8 Butan-1-ol and propanoic acid both have the same size molecules with a molar mass of $74 \text{ g}\cdot\text{mol}^{-1}$. Butan-1-ol has a boiling point of $117,7^\circ\text{C}$ while propanoic acid has a boiling point of $141,2^\circ\text{C}$. Fully explain the difference in boiling points of these two compounds. (5)

Additional Writing Space

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