Name: _____

GRADE 12 **PHYSICAL SCIENCE** 3 HOURS
TRIALS **PAPER 2 (CHEMISTRY)** 150 MARKS

PLEASE READ THE FOLLOWING INSTRUCTIONS CAREFULLY

1. This paper consists of:

- a question paper of 7 pages
- a data and formula booklet of 2 pages
- 2 sheets of graph paper

Make sure that your question paper is complete.

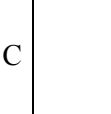
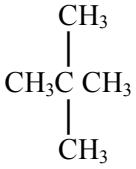
2. Remove the pages of data and formulae from the end of this question paper.

3. Use the data and formulae whenever necessary.

4. Read the questions carefully.

5. It is in your own interest to write legibly and to set your work out neatly.

QUESTION 1

A	C_3H_8		F	CH_3COOCH_3
B	2-pentene		G	$CH_3CH_2CH_2F$
C			H	
D	$CH_3CH_2CH_2OH$		I	$CH_3CH_2CH_2CH_2COOH$
E	$CH_3CH_2CH_2CH_2CH_3$		J	1,2-dibromobutane

1.1 Give the letters of two compounds which are isomers of one another. (2)

1.2 What is meant by the term 'isomers'? (1)

1.3 Write down the letter of a compound which is a saturated hydrocarbon. (1)

1.4 What is meant by the term 'saturated'? (1)

1.5 What is the functional group of compound D? (1)

1.6 To which homologous series does compound F belong? (1)

1.7 Give the IUPAC name of compound G. (1)

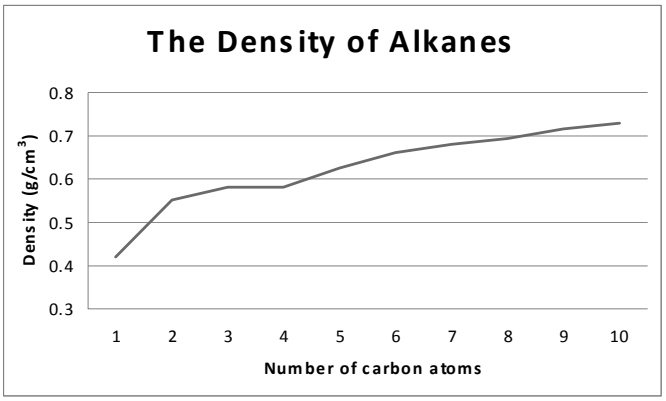
1.8 Draw the full structural formula of compound B. (1)

1.9 Which compound will have a higher boiling point, E or I? Fully explain your choice. (3)

1.10 Write a balanced equation for the substitution reaction in which compound G is a reactant and compound D is a product. Be sure to include all necessary reactants and products. (2)

1.11 Write down a balanced equation for the combustion reaction of compound H. You must use molecular formulas to represent all reactants and products. (2)

The graph below relates the density of straight-chain alkanes to the number of carbons in the chain.



1.12 Use the graph to estimate the density of propane. (1)

1.13 Use the graph to estimate the density of octane. (1)

1.14 Based on the information in the graph, make a conclusion about the relationship between the number of carbon atoms in an alkane molecule and the density of the compound. (2)

QUESTION 2

The organic compound 2-methyl 3-hexene can easily react with Br_2, resulting in the disappearance of the red-brown colour of bromine.

2.1 Name the reaction type described. (1)

2.2 Write a balanced equation for this reaction, using condensed formulas for all organic reactants and products. (3)

This reaction is used to investigate the effect of temperature on reaction rate. A spectrophotometer is used to determine the intensity of the red-brown colour over time, and therefore the percentage of Br_2 remaining. Hypothetical experimental results are recorded in the tables below.

Table 1 T = – 20˚C			**Table 2 T = 0˚C**			**Table 3 T = 20˚C**	
Time (s)	**% Br_2 remaining**		**Time (s)**	**% Br_2 remaining**		**Time (s)**	**% Br_2 remaining**
0	100		0	100		0	100
5	88		5	80		5	60
10	76		10	60		10	20
15	64		15	40		15	20
20	52		20	20		20	20
25	40		25	20		25	20
30	28		30	20		30	20
35	20		35	20		35	20
40	20		40	20		40	20

2.3 State a suitable hypothesis for this investigation. (1)

2.4 State the independent variable. (1)

2.5 State the dependent variable. (1)

2.6 Name one variable which must be kept constant in order for the experimental results to be valid. (1)

2.7 Based on the data provided, state the relationship between temperature and reaction rate. (1)

2.8 Explain this relationship in terms of collision theory. (3)

2.9 Sketch a graph of number of reactant particles (on the y-axis) vs. kinetic energy (on the x-axis) to illustrate how temperature of reactants affects reaction rate. (3)

QUESTION 3

The chlor-alkali industry is one of the most significant sectors of chemical manufacturing. It is also the one with the longest history. In its early days, the most important product of the chlor-alkali process was sodium hydroxide, required for the manufacture of soap. More recently, the product of greatest value is chlorine, used for the manufacture of the plastic known as polyvinylchloride (PVC). PVC is an addition polymer made of the monomer 1-chloroethene.

3.1 Draw the structural formula of 1-chloroethene. (1)

3.2 Draw a diagram to represent the polymer PVC, showing at least 4 repeating units. (2)

3.3 List, in order, the names of the three steps involved in addition polymerisation (ie. the formation of an addition polymer from its monomer units). (3)

3.4 State in words what occurs during the first step. (2)

3.5 Illustrate the first step process using the monomer of PVC as an example. (2)

3.6 During which of the three steps of polymerisation could branching occur? (1)

3.7 List two advantages and two disadvantages of materials composed of polymers. (4)

The chlor-alkali process is based on the electrolysis of brine.

3.8 Clearly define what is meant by each of the underlined words in this statement. (2)

3.9 List the formula of each the three products of the chlor-alkali process and give a use of each one (besides those uses already mentioned in the question). (4)

A diagram of the membrane cell used in the chlor-alkali industry is shown below. Some relevant equations as written on the Table of Standard Reduction potentials are:

$Na^+ + e^-$	$\rightleftharpoons$	Na	$-2,71V$
$2H_2O + 2e^-$	$\rightleftharpoons$	$H_2 + 2OH^-$	$-0,83V$
$O_2 + 4H^+ + 4e^-$	$\rightleftharpoons$	$2H_2O$	$+1,23V$
$Cl_2 + 2e^-$	$\rightleftharpoons$	$2Cl^-$	$+1,36V$

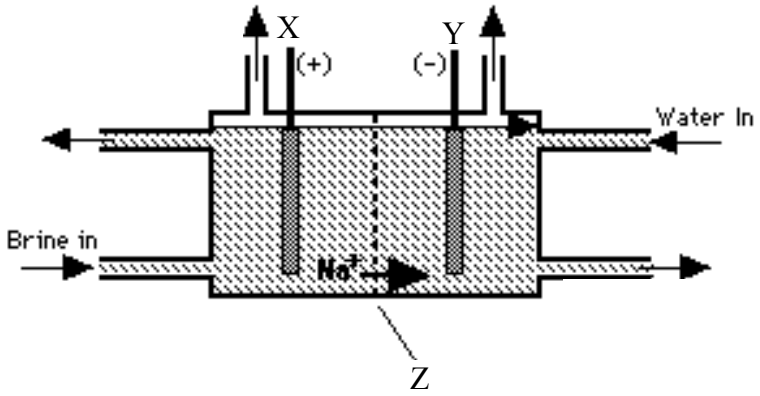


Diagram of the chlor-alkali membrane cell

3.10 Electrode X is positively charged in this electrolytic cell. State the name for this electrode as well as the type of half reaction that takes place here. (2)

3.11 Write down the half reaction that takes place at electrode X. (2)

3.12 Write down the half reaction that takes place at electrode Y. (2)

3.13 State the function of the membrane Z. (1)

The membrane cell is the most economical and environmentally friendly of the three cells used for the electrolysis of brine.

3.14 Name the two other cells used for the electrolysis of brine. For each one, state and explain the environmental/health reason why it is being discontinued in favour of the membrane cell. (6)

3.15 State the main safety risk of the chlor-alkali process, regardless of which cell is used. (1)

QUESTION 4

The production of sulphuric acid (H_2SO_4) is another important worldwide chemical industry. Amongst a wide range of other uses, sulphuric acid is the electrolyte in lead-acid cells and it plays an essential role in the production of phosphate fertilisers.

4.1 What is the role of the electrolyte in an electrochemical cell? (1)

4.2 What is the most common use of lead-acid cells? (1)

4.3 Are lead-acid cells primary cells or are they secondary cells? Explain what this means and briefly discuss the impact this fact has on the environment. (4)

One method of production of sulphuric acid is the 3-step contact process. The second step of the contact process is written below:

$$2SO_2\,(g) + O_2\,(g) \quad \rightleftharpoons \quad 2SO_3\,(g) \qquad \Delta H = -98kJ$$

4.4 Write down an expression for the equilibrium constant for this reaction. (2)

4.5 List three methods that could be used to increase the rate of this reaction. (3)

4.6 State one advantage and one disadvantage of increasing the rate of a chemical reaction in an industrial context. (4)

4.7 Which of the methods you listed in 4.5 would also increase the yield of SO_3? List all that apply. (1)

QUESTION 5

Tertiary butyl bromide is converted to tertiary butyl alcohol according to the reaction:

$$(CH_3)_3CBr\,(aq) + H_2O\,(l) \rightarrow (CH_3)_3COH\,(aq) + HBr\,(aq)$$

5.1 What type of organic reaction is occurring? (1)

Table 4. Reaction data collected at 25ºC

Time (h)	$[(CH_3)_3CBr]$ ($mol \cdot dm^{-3}$)	Reaction rate (h^{-1})
0	0,1039	
3,15	0,0896	0,00454
4,10	0,0859	0,00395
6,20	0,0776	0,00389
8,20	0,0701	0,00375
10,0	0,0639	0,00344

5.2 Use the experimental data to plot a rate-versus-time on the graph paper provided. Show the data points and connect them together using a smooth line. (5)

5.3 What happens to the reaction rate as time passes during the reaction? (1)

5.4 Explain this relationship in terms of collision theory. (3)

Suzanne wishes to use this reaction to investigate the effect of a catalyst on reaction rate.

5.5 State a suitable investigative question for Suzanne's experiment. (1)

5.6 What is Suzanne's dependent variable? (1)

5.7 State two variables that she must control or keep constant during her investigation. (2)

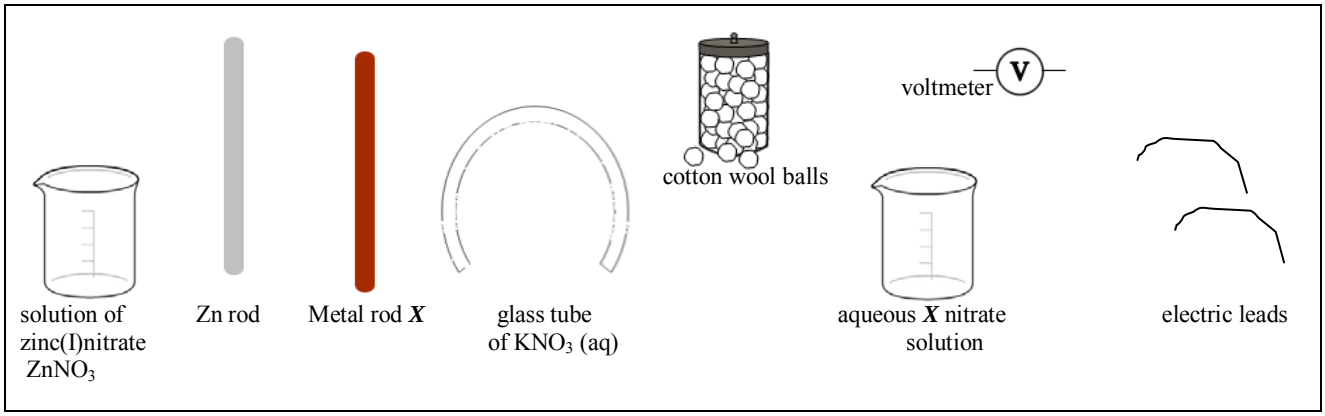
5.8 On a new piece of graph paper (provided), sketch a concentration-versus-time graph using the data in Table 4. Show the data points and connect them together using a smooth line. Clearly label your line as 'data set 1'. (6)

5.9 On the same set of axes as data set 1, sketch a possible concentration-versus-time graph for the same reaction but with the inclusion of a suitable catalyst. Clearly label your predicted line as 'data set 2'. (3)

5.10 Explain the effect of a catalyst on reaction rate in terms of collision theory. (2)

QUESTION 6

Vivianne finds a piece of unknown metal ***X*** and sets out to identify it using a standard electrochemical cell. She collects the equipment shown below. She guesses what the metal might be, and uses an aqueous nitrate solution of its ions (***X*** nitrate) in one beaker.



6.1 Draw a labelled diagram of the experimental setup Vivianne will need to use for this experiment. (6)

6.2 State two standard conditions, which would apply to this cell. (2)

6.3 Immediately after setting up the experiment, Vivianne notes that the voltmeter reads 1,56V. After some time passes she observes that the mass of the zinc electrode has decreased and the mass of the unknown metal electrode has increased. Calculate the standard electrode potential of metal ***X***. (3)

6.4 Identify metal ***X***. (1)

6.5 Write the balanced equation for the half-reaction that occurs at metal ***X***. (1)

6.6 Write down the name or formula of the reducing agent in the cell. (1)

6.7 After Vivianne's cell has been operating for quite some time, she notes that the reading on the voltmeter has dropped from 1,56V to 0,75V. State the reason for this change. (1)

6.8 Describe one change that could be made to the structure of this cell in order to increase the current that it supplies. Explain how this change will lead to greater cell current. (3)

QUESTION 7

Table 5. Summary of cell specifications for four cells

Cell	Cell voltage (volts)	Cell capacity (Amp-hours)	Cell capacity (Coulombs)
A	5	50	
B	5	110	
C	12	50	
D	12	110	

7.1 Show that 1 Amp-hour is equivalent to 3600C of charge and use this fact to calculate the cell capacity for each cell in units of Coulombs. (4)

7.2 Use the information in the table to calculate the energy stored in each cell. (4)

7.3 Which cell stores the most energy? (1)

Alessandro Volta invented the first modern battery in the late 1700s. The zinc-carbon dry cell was invented by Leclanche in 1868. Since then, a large number of different battery types have been introduced, including nickel-cadmium rechargeables, alkaline disposables, and the very modern lithium-ion batteries.

7.4 The Leclanche cell is an example of a dry cell. What does this mean, and what is the advantage of this fact? (2)

7.5 List 3 specific uses of these types of cells. (3)

7.6 List two positive and two negative impacts of batteries on human society and on the environment. (4)

7.7 Use the Table of Standard Reduction potentials to write out the half reactions for a nickel-cadmium cell while it is operating. (2)

7.8 What is the emf of a nickel-cadmium cell? (1)

TOTAL FOR THIS PAPER: 150 MARKS