HILLCREST HIGH SCHOOL
PHYSICAL SCIENCE
GRADE 11
PAPER 2- Chemistry

JUNE 2022
TIME: 3 HRS

Total: 150

Instructions

1. Answer ALL the questions.

2. This question paper consists of TWO sections:

3. SECTION A (20)
   SECTION B (130)

   Answer SECTIONS A and B in the ANSWER BOOK.

4. Non-programmable calculators may be used.

5. Appropriate mathematical instruments may be used.

6. Number the answers correctly according to the numbering system used in this question paper.

7. Data sheets and a periodic table are attached for your use.

8. Give brief motivations, discussions, et cetera where required.

9. Numbers must be rounded off to **two decimal** places.

SECTION A

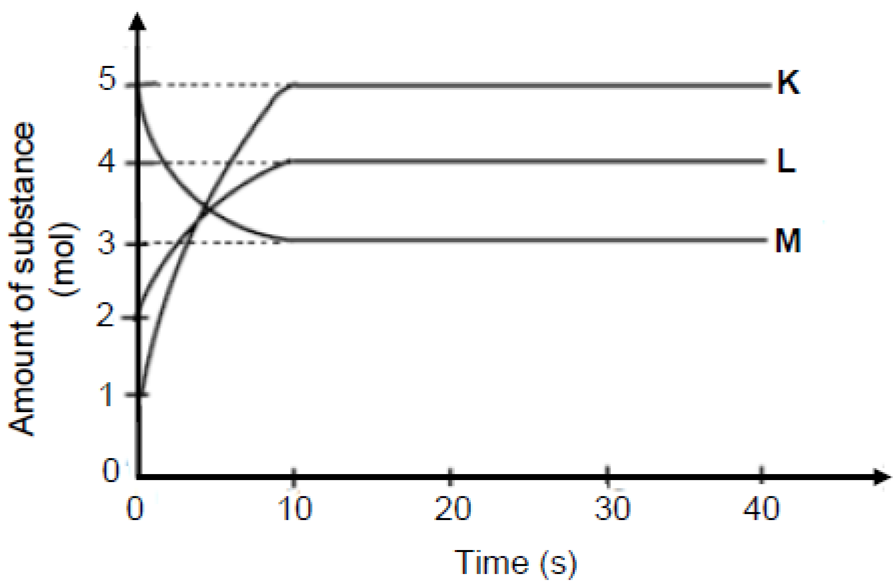
QUESTION 1: MULTIPLE-CHOICE QUESTIONS

Four options are provided as possible answers to the following questions. Each question has only ONE correct answer. Write only the letter (A – D) next to the question number (1.1 – 1.10) in the ANSWER BOOK.

1.1 The percentage oxygen in $CuSO_4{\cdot}5H_2O$ is:

A 40,13 %
B 25,65 %
C 43,13 %
D 57.72 %

1.2 The graph below shows the relationship between the amount of substance and time in a chemical reaction involving substances K, L and M.



The equation for the reaction can be represented as:

A $3M \rightarrow 4K + 5L$
B $5M \rightarrow 2K + L$
C $M \rightarrow 2K + L$
D $M \rightarrow K + 2L$

1.3 Given the reaction $N_2(g) + O_2(g) \rightarrow 2\ NO(g)$

The activation energy for the forward reaction is 181,5 kJ and for the reverse reaction is 192,8 kJ. What is the heat of reaction for the forward reaction?

A -374,3 kJ

B +374,3 kJ

C -11,3 kJ

D +11,3 kJ

1.4 Consider the following reaction:

$$Mg(s) + 2HC\ell\,(aq) \rightarrow H_2(g) + MgC\ell_2\,(aq)$$

The rate of the reaction increases when more magnesium is added.
This change is caused by the ...

A increase in surface area
B addition of a catalyst
C increase in concentration of reactants
D change in nature of the reactants

1.5 A solution of ethanoic acid (acetic acid) is titrated against a standard sodium hydroxide solution. Which ONE of the following indicators would be the most suitable for this titration?

	Indicator	pH range of the indicator
A	Phenolphthalein	8,3 - 10
B	Methyl orange	3,1 – 4,4
C	Bromothymol blue	6,0 – 7,6
D	Universal indicator	Changes colour over a wide range of pH values

1.6 Solid X has a low melting point and dissolves easily in a non-polar solvent.
Solid Y has a high melting point and dissolves easily in a polar solvent.
Solids X and Y are …

	Solid X	**Solid Y**
A	H_2O	I_2
B	I_2	KCℓ
C	NaCℓ	KBr
D	I_2	C

1.7 HI has a higher boiling point than HCℓ.
Which statement is INCORRECT for this observation?

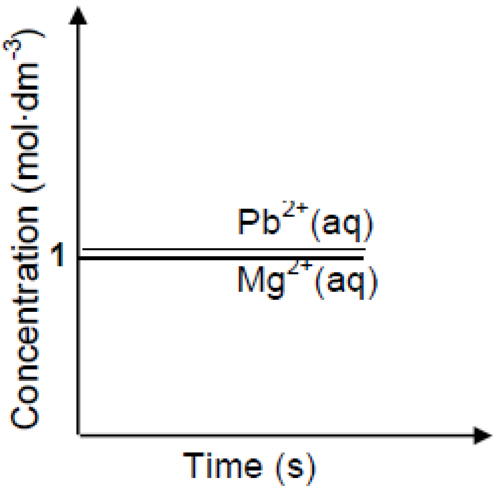
A The iodide ion is a larger ion than the chloride ion.
B The molar mass of HI is greater than the molar mass of HCℓ.
C There are more electrons in HI than HCℓ.
D Hydrogen bonding is present in HI.

1.8 An electrochemical cell is set up at standard conditions. The cell notation for the cell is given below.

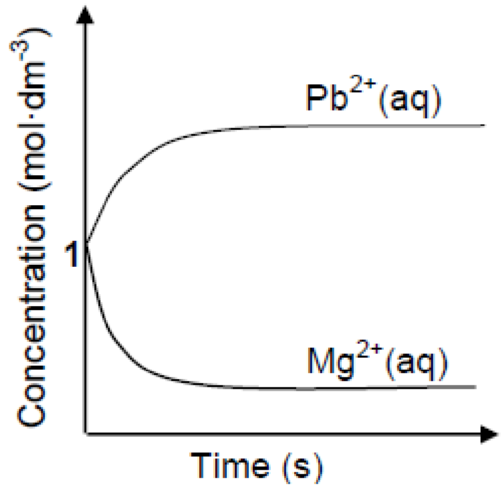
$$Mg(s) \mid Mg^{2+}(aq) \parallel Pb^{2+}(aq) \mid Pb(s)$$

The cell is now connected in a circuit. Which ONE of the graphs below BEST represents the concentrations of the electrolytes after a long time?

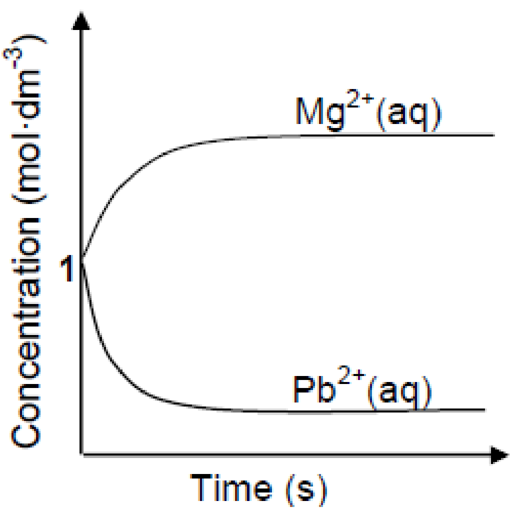
A



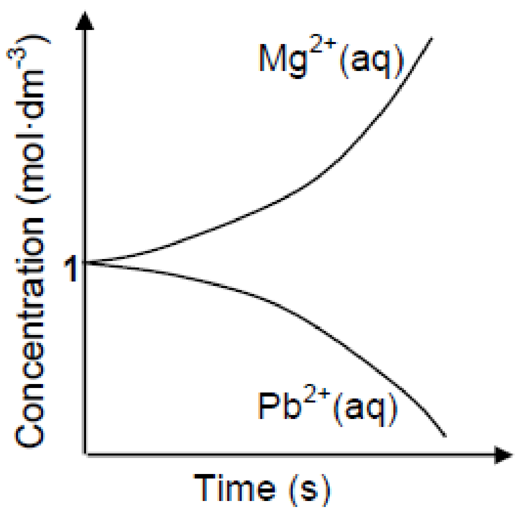
B



C



D



1.9 Which ONE of the following correctly describes the electrode in an ELECTROLYTIC cell and its polarity?

	Electrode	Polarity	Type of half-reaction
A	Anode	Positive	Reduction
B	Anode	Negative	Oxidation
C	Cathode	Negative	Reduction
D	Cathode	Positive	Oxidation

1.10 A silver spoon is placed in a pure copper(II) sulphate solution. Which ONE of the following best explains why no reaction will take place?

A Ag is a weaker reducing agent than Cu(II) ions.

B Ag is a weaker reducing agent than Cu.

C Ag is a weaker oxidising agent than Cu(II) ions.

D Ag ions is a weaker oxidising agent than Cu(II) ions.

[2 X 10 = 20]

SECTION B:

QUESTION 2:

Candle wax burns in oxygen to form carbon dioxide and water according to the following balanced equation:

$$C_{23}H_{48} + 35\ O_2 \rightarrow 23\ CO_2 + 24\ H_2O$$

In one such reaction 4,816 x 10^{22} molecules of candle wax reacts with 3 moles of oxygen.

2.1.1 Define *limiting reagent*. (2)

2.1.2 Determine which of candle wax or oxygen is the limiting reagent. (4)

2.1.3 Calculate the MAXIMUM mass of water that can be produced. (4)

2.1.4 It is found that the percentage yield of carbon dioxide is 90%. Calculate the ACTUAL volume of CO_2 collected if the molar volume of the gas is 23,2 dm^3 at 27°C. (4)

2.2 A compound has the following percentage composition:

58,065% C 7,527% H 34,408% O

Determine the molecular formula of this compound if its molar mass is 372 $g.mol^{-1}$. (5)

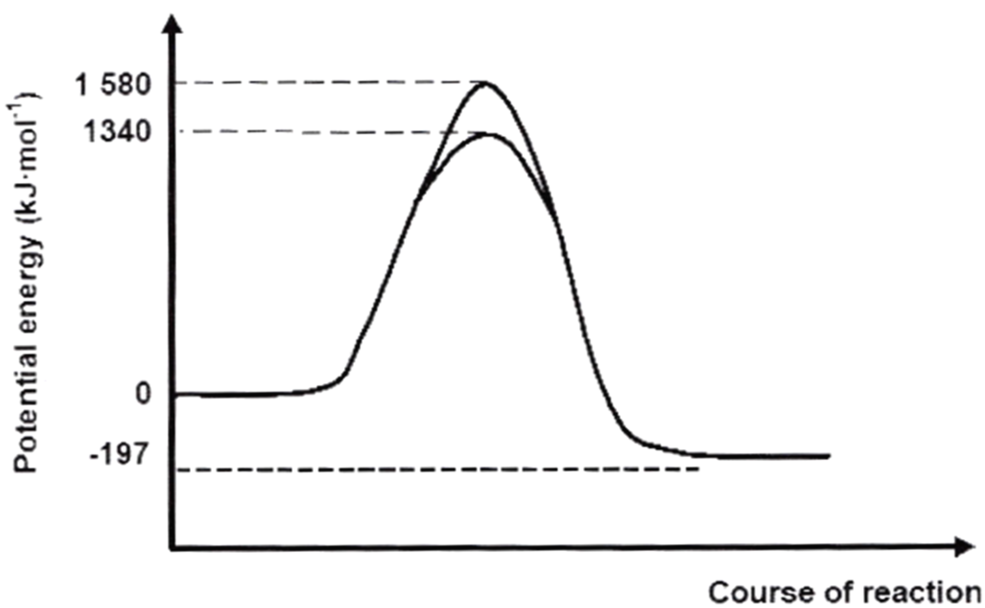
[19]

QUESTION 3:

The contact process is used to prepare sulphuric acid. This process involves the oxidation of sulphur dioxide in the presence of a vanadium (v) oxide catalyst, according to the following balanced reaction.

$$2\ SO_2\ (g) + O_2\ (g) \rightarrow 2\ SO_3\ (g)$$

Use the reaction and the graph, where applicable, to answer the questions that follow.



3.1 Is the forward reaction EXOTHERMIC or ENDOTHERMIC? (1)

3.2 Define *activation energy*. (2)

3.3 What is the activation energy for the forward reaction in the absence of the catalyst? (1)

3.4 If 1580 $kJ.mol^{-1}$ is needed to break the bonds in the SO_2 and O_2 molecules, how much energy is released when the SO_3 molecules are formed? (2)

3.5 Determine the activation energy for the REVERSE REACTION in the presence of the catalyst. (2)

3.6 How does the addition of a catalyst affect the value of ΔH? Write down INCREASES, DECREASES or REMAINS THE SAME. (1)

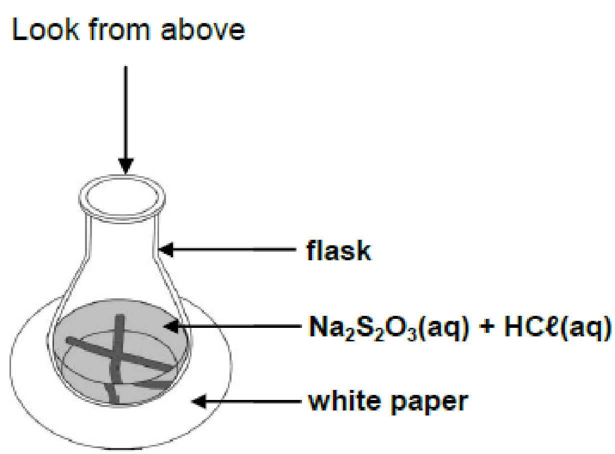
[9]

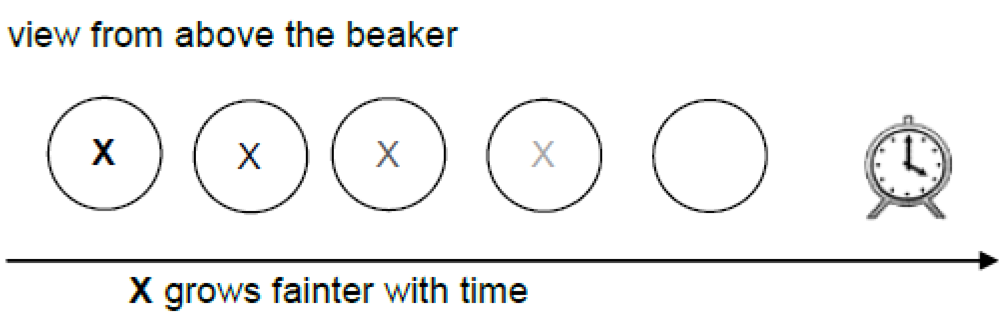
QUESTION 4:

A group of learners were investigating the factors affecting the reaction rate. In one of their reactions sodium thiosulphate ($Na_2S_2O_3$) and hydrochloric acid (HCl) are reacted according to the balanced equation given below:

$$Na_2S_2O_3\ (aq) + 2\ HCl\ (aq) \rightarrow 2\ NaCl\ (aq) + S\ (s) + H_2O\ (l) + SO_2\ (g)$$

During the reaction one of the products formed causes the solution to turn cloudy. Due to this, the mark **X** drawn on the paper, on which the reaction mixture is placed, was not visible after the reaction is completed. Refer to the sketch below.





In the investigation the learners took sodium thiosulphate of different concentrations and reacted it with hydrochloric acid of constant concentration. They recorded the time taken for the mark **X** on the paper to disappear. Their results are tabulated below.

Trial	1	2	3	4
Concentration $Na_2S_2O_3$(mol.dm^{-3})	0,15	0,09	0,06	0,03
Time taken for the X to disappear in (s)	43	66	100	240

4.1 Define the term *reaction rate*. (2)

4.2 For the experiment described above, name the:

4.2.1 Independent variable (1)

4.2.2 ONE controlled variable (1)

4.3 Write down the NAME or FORMULA of the substance responsible for the cloudiness (1)

4.4 Consider the table of results and write down which trial (1, 2, 3 or 4) occurred at the highest reaction rate? (1)

4.5 Draw a sketch graph to show how the concentration of the sodium thiosulphate will change against time for the mark **X** to disappear. (2)

4.6 Use the graph to make a conclusion for the above investigation. (2)

4.7 Name TWO other ways in which the rate of this reaction can be increased. (2)

[12]

QUESTION 5:

4.14 g of solid $LiNO_3$ is first dissolved in a small amount of water and then made up to a certain final volume so that the concentration of the solution is 0.05 $mol.dm^{-3}$.

5.1 Write down the definition of *concentration*. (2)

5.2 Calculate the number of moles of $LiNO_3$ used. (2)

5.3 Calculate the final volume of the solution. (3)

5.4 An additional 250 cm^3 of water is now added to this solution. Calculate the new concentration of the solution. (4)

[11]

QUESTION 6:

Two beakers, **A** and **B**, contain strong bases.

Beaker **A**: 500 cm^3 of barium hydroxide, $Ba(OH)_2$ (aq) of unknown concentration **X**

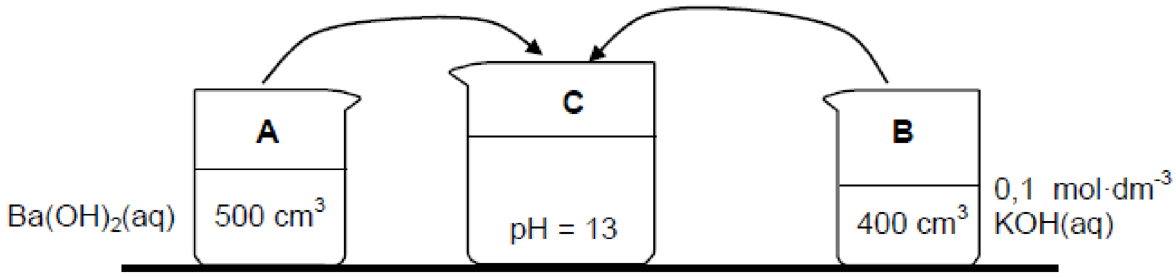
Beaker **B**: 400 cm^3 of potassium hydroxide, KOH (aq) of concentration 0,1 $mol.dm^{-3}$

6.1 Define a *base* according to the Arrhenius theory. (2)

6.2 Calculate the number of moles of hydroxide ions (OH^-) in beaker **B**. (2)

6.3 The contents of beakers **A** and **B** are added together in beaker C. The solution in Beaker C has a pH of 13.

Assume that the volumes are additive and that the temperature of the solutions is at 25°C.



6.3.1 Calculate the concentration, **X**, of the $Ba(OH)_2$ in beaker **A**. (8)

The solution in beaker **C** is titrated with ethanoic acid. It was found that 15 cm^3 of the solution neutralises 30 cm^3 of the acid.

The balanced equation for the reaction is:

$$CH_3COOH\ (aq) + OH^-\ (aq) \rightarrow CH_3COO^-\ (aq) + H_2O\ (l)$$

6.3.2 Is ethanoic acid, CH_3COOH (aq), a WEAK acid or a STRONG acid? Give a reason for the answer. (2)

6.3.3 Calculate the concentration of the ethanoic acid. (4)

[18]

QUESTION 7:

Study the reaction below:

$$Mg\ (s) + I_2\ (s) \rightarrow Mg^{2+}\ (aq) + I^-\ (aq)$$

7.1 Define *reducing agent* in terms of oxidation numbers. (2)

7.2 Identify the reducing agent in the above reaction. (1)

7.3 Write down the FORMULA of the substance that is reduced. (1)

7.4 Write down the balanced equation for:

7.4.1 the oxidation half reaction. (2)

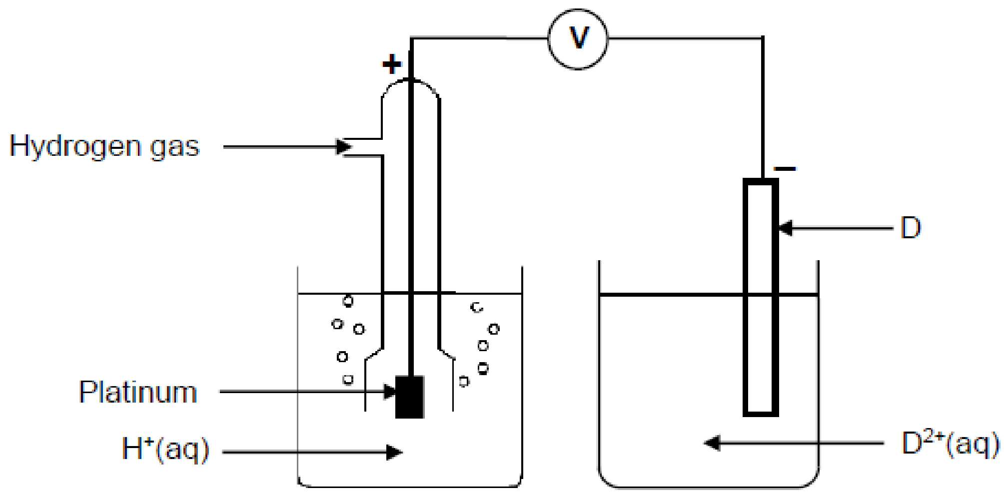
7.4.2 the reduction half reaction. (2)

7.4.3 the overall reaction. (2)

[10]

QUESTION 8:

A learner sets up a standard electrochemical cell using a standard hydrogen half-cell and an unknown standard half-cell D|D^{2+} as shown below.



8.1 Name the type of electrochemical cell that converts chemical energy to electrical energy. (1)

8.2 It is found that there is no reading on the voltmeter. Give a reason for this observation (1)

The learner now makes the necessary change to the above setup and the voltmeter registers a reading of 0,24 V.

8.3 Write down the half-reaction that takes place at the cathode of this cell whilst it is functioning.

(2)

8.4 The hydrogen half-cell is now replaced by a J|J^{2+} half-cell. The cell notation of this cell is:

$$J\ (s)\ |\ J^{2+}\ (aq)\ ||\ D^{2+}\ (aq)\ |\ D\ (s)$$

The initial reading on the voltmeter is now 1,42 V.

8.4.1 What does the single line (|) in the above cell notation represent? (1)

8.4.2 Identify metal **J**. Show how you arrived at the answer. (5)

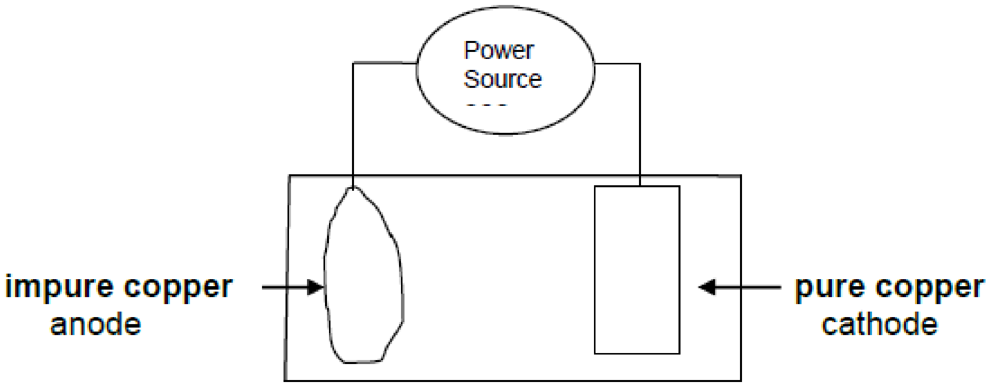
8.4.3 Is the cell reaction EXOTHERMIC or ENDOTHERMIC? (1)

8.5 Give two standard condition for this cell. (2)

[13]

QUESTION 9:

A learner sets up an electrolytic cell, represented in the diagram below, to purify copper which contains platinum and silver impurities.



During the purification of 28 g of the impure copper, 0,8 mol of electrons were transferred from the anode to the cathode.

9.1 Calculate the number of copper atoms formed at the cathode. (3)

9.2 The copper used for electrical wiring and cables must be 99,99% pure. Determine by calculation whether the IMPURE copper sample is suitable for use in electric wiring and cables.
(Assume that all the copper at the anode has reacted) (5)

During the purification, a sludge containing the metals platinum and silver forms at the bottom of the container.

9.3 Use the relative strengths of reducing agents to explain why platinum and silver atoms are not oxidised during the purification of copper. (3)

[11]

QUESTION 10:

In an experiment to determine the relationship between boiling point and the molar mass, learners heated equal amounts of different substances.

ELEMENT	MOLAR MASS ($g.mol^{-1}$)	MELTING POINT (°C)
F_2	38	-223
$C\ell_2$	71	-102
Br_2	160	-7,3
I_2	254	113

10.1 In what phase, liquid or gas, does Br_2 exist at 25°C? (1)

10.2 Define the term *melting point*. (2)

10.3 State the dependent variable for this investigation. (1)

10.4 State the controlled variable. (1)

10.5 Which of the above substances will have the lowest vapour pressure? (1)

10.6 How do the melting points of the molecules change going from F_2 to I_2? (1)

10.7 Explain the trend in melting points from F_2 to I_2 with reference to the forces between the molecules and the energy needed to break the bonds? (4)

[11]

QUESTION 11:

11.1 State the definition of a *covalent bond*. (2)

Consider the following list of substances and answer the questions that follow.

HF BCl_3 CF_4 NH_3 CO_2 SCl_6

11.2 From the list write down the formula/e of:

11.2.1 the molecule that has an octahedral shape (1)

11.2.2 a substance that can sublime at room temperature (1)

11.3 BCl_3 can form a dative covalent bond with NH_3.

11.3.1 Draw the Lewis structure for the BCl_3 molecule. (2)

11.3.2 What is the shape of the BCl_3 molecule? (1)

11.3.3 Explain why NH_3 is able to form a dative covalent bond with BCl_3. (2)

11.4 Explain why the bonds in CF_4 are polar, but the molecule is non-polar. (3)

[12]

QUESTION 12:

The pressure of an unknown gas is increased by 20%. Calculate the final volume of the gas if the original volume was 20 dm^3. (4)

[4]

Total : 150

TABLE 4A: STANDARD REDUCTION POTENTIALS
TABEL 4A: STANDAARD- REDUKSIEPOTENSIALE

Increasing oxidising ability/*Toenemende oksiderende vermoë* (↑)

Increasing reducing ability/*Toenemende reduserende vermoë* (↓)

Half-reactions/*Halfreaksies*			E^{θ} (V)
$F_2(g) + 2e^-$	$\rightleftharpoons$	$2F^-$	+ 2,87
$Co^{3+} + e^-$	$\rightleftharpoons$	Co^{2+}	+ 1,81
$H_2O_2 + 2H^+ + 2e^-$	$\rightleftharpoons$	$2H_2O$	+1,77
$MnO_4^- + 8H^+ + 5e^-$	$\rightleftharpoons$	$Mn^{2+} + 4H_2O$	+ 1,51
$C\ell_2(g) + 2e^-$	$\rightleftharpoons$	$2C\ell^-$	+ 1,36
$Cr_2O_7^{2-} + 14H^+ + 6e^-$	$\rightleftharpoons$	$2Cr^{3+} + 7H_2O$	+ 1,33
$O_2(g) + 4H^+ + 4e^-$	$\rightleftharpoons$	$2H_2O$	+ 1,23
$MnO_2 + 4H^+ + 2e^-$	$\rightleftharpoons$	$Mn^{2+} + 2H_2O$	+ 1,23
$Pt^{2+} + 2e^-$	$\rightleftharpoons$	Pt	+ 1,20
$Br_2(\ell) + 2e^-$	$\rightleftharpoons$	$2Br^-$	+ 1,07
$NO_3^- + 4H^+ + 3e^-$	$\rightleftharpoons$	$NO(g) + 2H_2O$	+ 0,96
$Hg^{2+} + 2e^-$	$\rightleftharpoons$	$Hg(\ell)$	+ 0,85
$Ag^+ + e^-$	$\rightleftharpoons$	Ag	+ 0,80
$NO_3^- + 2H^+ + e^-$	$\rightleftharpoons$	$NO_2(g) + H_2O$	+ 0,80
$Fe^{3+} + e^-$	$\rightleftharpoons$	Fe^{2+}	+ 0,77
$O_2(g) + 2H^+ + 2e^-$	$\rightleftharpoons$	H_2O_2	+ 0,68
$I_2 + 2e^-$	$\rightleftharpoons$	$2I^-$	+ 0,54
$Cu^+ + e^-$	$\rightleftharpoons$	Cu	+ 0,52
$SO_2 + 4H^+ + 4e^-$	$\rightleftharpoons$	$S + 2H_2O$	+ 0,45
$2H_2O + O_2 + 4e^-$	$\rightleftharpoons$	$4OH^-$	+ 0,40
$Cu^{2+} + 2e^-$	$\rightleftharpoons$	Cu	+ 0,34
$SO_4^{2-} + 4H^+ + 2e^-$	$\rightleftharpoons$	$SO_2(g) + 2H_2O$	+ 0,17
$Cu^{2+} + e^-$	$\rightleftharpoons$	Cu^+	+ 0,16
$Sn^{4+} + 2e^-$	$\rightleftharpoons$	Sn^{2+}	+ 0,15
$S + 2H^+ + 2e^-$	$\rightleftharpoons$	$H_2S(g)$	+ 0,14
$\mathbf{2H^+ + 2e^-}$	$\rightleftharpoons$	$\mathbf{H_2(g)}$	**0,00**
$Fe^{3+} + 3e^-$	$\rightleftharpoons$	Fe	− 0,06
$Pb^{2+} + 2e^-$	$\rightleftharpoons$	Pb	− 0,13
$Sn^{2+} + 2e^-$	$\rightleftharpoons$	Sn	− 0,14
$Ni^{2+} + 2e^-$	$\rightleftharpoons$	Ni	− 0,27
$Co^{2+} + 2e^-$	$\rightleftharpoons$	Co	− 0,28
$Cd^{2+} + 2e^-$	$\rightleftharpoons$	Cd	− 0,40
$Cr^{3+} + e^-$	$\rightleftharpoons$	Cr^{2+}	− 0,41
$Fe^{2+} + 2e^-$	$\rightleftharpoons$	Fe	− 0,44
$Cr^{3+} + 3e^-$	$\rightleftharpoons$	Cr	− 0,74
$Zn^{2+} + 2e^-$	$\rightleftharpoons$	Zn	− 0,76
$2H_2O + 2e^-$	$\rightleftharpoons$	$H_2(g) + 2OH^-$	− 0,83
$Cr^{2+} + 2e^-$	$\rightleftharpoons$	Cr	− 0,91
$Mn^{2+} + 2e^-$	$\rightleftharpoons$	Mn	− 1,18
$A\ell^{3+} + 3e^-$	$\rightleftharpoons$	$A\ell$	− 1,66
$Mg^{2+} + 2e^-$	$\rightleftharpoons$	Mg	− 2,36
$Na^+ + e^-$	$\rightleftharpoons$	Na	− 2,71
$Ca^{2+} + 2e^-$	$\rightleftharpoons$	Ca	− 2,87
$Sr^{2+} + 2e^-$	$\rightleftharpoons$	Sr	− 2,89
$Ba^{2+} + 2e^-$	$\rightleftharpoons$	Ba	− 2,90
$Cs^+ + e^-$	$\rightleftharpoons$	Cs	- 2,92
$K^+ + e^-$	$\rightleftharpoons$	K	− 2,93
$Li^+ + e^-$	$\rightleftharpoons$	Li	− 3,05

TABLE 4B: STANDARD REDUCTION POTENTIALS
TABEL 4B: STANDAARD- REDUKSIEPOTENSIALE

Half-reactions/*Halfreaksies*			E^{θ} (V)
$Li^+ + e^-$	⇌	Li	− 3,05
$K^+ + e^-$	⇌	K	− 2,93
$Cs^+ + e^-$	⇌	Cs	− 2,92
$Ba^{2+} + 2e^-$	⇌	Ba	− 2,90
$Sr^{2+} + 2e^-$	⇌	Sr	− 2,89
$Ca^{2+} + 2e^-$	⇌	Ca	− 2,87
$Na^+ + e^-$	⇌	Na	− 2,71
$Mg^{2+} + 2e^-$	⇌	Mg	− 2,36
$A\ell^{3+} + 3e^-$	⇌	$A\ell$	− 1,66
$Mn^{2+} + 2e^-$	⇌	Mn	− 1,18
$Cr^{2+} + 2e^-$	⇌	Cr	− 0,91
$2H_2O + 2e^-$	⇌	$H_2(g) + 2OH^-$	− 0,83
$Zn^{2+} + 2e^-$	⇌	Zn	− 0,76
$Cr^{3+} + 3e^-$	⇌	Cr	− 0,74
$Fe^{2+} + 2e^-$	⇌	Fe	− 0,44
$Cr^{3+} + e^-$	⇌	Cr^{2+}	− 0,41
$Cd^{2+} + 2e^-$	⇌	Cd	− 0,40
$Co^{2+} + 2e^-$	⇌	Co	− 0,28
$Ni^{2+} + 2e^-$	⇌	Ni	− 0,27
$Sn^{2+} + 2e^-$	⇌	Sn	− 0,14
$Pb^{2+} + 2e^-$	⇌	Pb	− 0,13
$Fe^{3+} + 3e^-$	⇌	Fe	− 0,06
$2H^+ + 2e^-$	**⇌**	**$H_2(g)$**	**0,00**
$S + 2H^+ + 2e^-$	⇌	$H_2S(g)$	+ 0,14
$Sn^{4+} + 2e^-$	⇌	Sn^{2+}	+ 0,15
$Cu^{2+} + e^-$	⇌	Cu^+	+ 0,16
$SO_4^{2-} + 4H^+ + 2e^-$	⇌	$SO_2(g) + 2H_2O$	+ 0,17
$Cu^{2+} + 2e^-$	⇌	Cu	+ 0,34
$2H_2O + O_2 + 4e^-$	⇌	$4OH^-$	+ 0,40
$SO_2 + 4H^+ + 4e^-$	⇌	$S + 2H_2O$	+ 0,45
$Cu^+ + e^-$	⇌	Cu	+ 0,52
$I_2 + 2e^-$	⇌	$2I^-$	+ 0,54
$O_2(g) + 2H^+ + 2e^-$	⇌	H_2O_2	+ 0,68
$Fe^{3+} + e^-$	⇌	Fe^{2+}	+ 0,77
$NO_3^- + 2H^+ + e^-$	⇌	$NO_2(g) + H_2O$	+ 0,80
$Ag^+ + e^-$	⇌	Ag	+ 0,80
$Hg^{2+} + 2e^-$	⇌	$Hg(\ell)$	+ 0,85
$NO_3^- + 4H^+ + 3e^-$	⇌	$NO(g) + 2H_2O$	+ 0,96
$Br_2(\ell) + 2e^-$	⇌	$2Br^-$	+ 1,07
$Pt^{2+} + 2e^-$	⇌	Pt	+ 1,20
$MnO_2 + 4H^+ + 2e^-$	⇌	$Mn^{2+} + 2H_2O$	+ 1,23
$O_2(g) + 4H^+ + 4e^-$	⇌	$2H_2O$	+ 1,23
$Cr_2O_7^{2-} + 14H^+ + 6e^-$	⇌	$2Cr^{3+} + 7H_2O$	+ 1,33
$C\ell_2(g) + 2e^-$	⇌	$2C\ell^-$	+ 1,36
$MnO_4^- + 8H^+ + 5e^-$	⇌	$Mn^{2+} + 4H_2O$	+ 1,51
$H_2O_2 + 2H^+ + 2e^-$	⇌	$2H_2O$	+1,77
$Co^{3+} + e^-$	⇌	Co^{2+}	+ 1,81
$F_2(g) + 2e^-$	⇌	$2F^-$	+ 2,87

Increasing oxidising ability/*Toenemende oksiderende vermoë* ↓

Increasing reducing ability/*Toenemende reduserende vermoë* ↑

NAME/*NAAM*	SYMBOL/*SIMBOOL*	VALUE/*WAARDE*
Avogadro's constant *Avogadro-konstante*	N_A	$6{,}02 \times 10^{23}$ mol^{-1}
Molar gas constant *Molêre gaskonstante*	R	$8{,}31$ $J \cdot K^{-1} \cdot mol^{-1}$
Standard pressure Standaarddruk	p^{θ}	$1{,}013 \times 10^{5}$ Pa
Molar gas volume at STP *Molêre gasvolume by STD*	V_m	$22{,}4$ $dm^{3} \cdot mol^{-1}$
Standard temperature *Standaardtemperatuur*	T^{θ}	273 K

TABLE 2: FORMULAE/*TABEL 2: FORMULES*

$n = \frac{m}{M}$	$n = \frac{N}{N_A}$
$c = \frac{n}{V}$ or/*of* $c = \frac{m}{MV}$	$n = \frac{V}{V_m}$
$\frac{c_a V_a}{c_b V_b} = \frac{n_a}{n_b}$	$pH = -\log[H_3O^+]$
$K_w = [H_3O^+][OH^-] = 1 \times 10^{-14}$ at/*by* 298 K	
$E^{\theta}_{cell} = E^{\theta}_{cathode} - E^{\theta}_{anode}$ / $E^{\theta}_{sel} = E^{\theta}_{katode} - E^{\theta}_{anode}$ or/*of* $E^{\theta}_{cell} = E^{\theta}_{reduction} - E^{\theta}_{oxidation}$ / $E^{\theta}_{sel} = E^{\theta}_{reduksie} - E^{\theta}_{oksidasie}$ or/*of* $E^{\theta}_{cell} = E^{\theta}_{oxidising\ agent} - E^{\theta}_{reducing\ agent}$ / $E^{\theta}_{sel} = E^{\theta}_{oksideermiddel} - E^{\theta}_{reduseermiddel}$	

$\frac{p_1 V_1}{T_1} = \frac{p_2 V_2}{T_2}$	$pV = nRT$

TABLE 3: THE PERIODIC TABLE OF ELEMENTS
TABEL 3: DIE PERIODIEKE TABEL VAN ELEMENTE

KEY/*SLEUTEL*

Atomic number / *Atoomgetal*	29
Symbol / *Simbool*	Cu
Approximate relative atomic mass / *Benaderde relatiewe atoommassa*	63,5
Electronegativity / *Elektronegatiwiteit*	1,9

Cells are given as: atomic number, symbol, approximate relative atomic mass (electronegativity).

1 (I)	2 (II)	3	4	5	6	7	8	9	10	11	12	13 (III)	14 (IV)	15 (V)	16 (VI)	17 (VII)	18 (VIII)
1 H 1 (2,1)																	2 He 4
3 Li 7 (1,0)	4 Be 9 (1,5)											5 B 11 (2,0)	6 C 12 (2,5)	7 N 14 (3,0)	8 O 16 (3,5)	9 F 19 (4,0)	10 Ne 20
11 Na 23 (0,9)	12 Mg 24 (1,2)											13 Aℓ 27 (1,5)	14 Si 28 (1,8)	15 P 31 (2,1)	16 S 32 (2,5)	17 Cℓ 35,5 (3,0)	18 Ar 40
19 K 39 (0,8)	20 Ca 40 (1,0)	21 Sc 45 (1,3)	22 Ti 48 (1,5)	23 V 51 (1,6)	24 Cr 52 (1,6)	25 Mn 55 (1,5)	26 Fe 56 (1,8)	27 Co 59 (1,8)	28 Ni 59 (1,8)	29 Cu 63,5 (1,9)	30 Zn 65 (1,6)	31 Ga 70 (1,6)	32 Ge 73 (1,8)	33 As 75 (2,0)	34 Se 79 (2,4)	35 Br 80 (2,8)	36 Kr 84
37 Rb 86 (0,8)	38 Sr 88 (1,0)	39 Y 89 (1,2)	40 Zr 91 (1,4)	41 Nb 92	42 Mo 96 (1,8)	43 Tc (1,9)	44 Ru 101 (2,2)	45 Rh 103 (2,2)	46 Pd 106 (2,2)	47 Ag 108 (1,9)	48 Cd 112 (1,7)	49 In 115 (1,7)	50 Sn 119 (1,8)	51 Sb 122 (1,9)	52 Te 128 (2,1)	53 I 127 (2,5)	54 Xe 131
55 Cs 133 (0,7)	56 Ba 137 (0,9)	57 La 139	72 Hf 179 (1,6)	73 Ta 181	74 W 184	75 Re 186	76 Os 190	77 Ir 192	78 Pt 195	79 Au 197	80 Hg 201	81 Tℓ 204 (1,8)	82 Pb 207 (1,8)	83 Bi 209 (1,9)	84 Po (2,0)	85 At (2,5)	86 Rn
87 Fr (0,7)	88 Ra 226 (0,9)	89 Ac															

58 Ce 140	59 Pr 141	60 Nd 144	61 Pm	62 Sm 150	63 Eu 152	64 Gd 157	65 Tb 159	66 Dy 163	67 Ho 165	68 Er 167	69 Tm 169	70 Yb 173	71 Lu 175
90 Th 232	91 Pa	92 U 238	93 Np	94 Pu	95 Am	96 Cm	97 Bk	98 Cf	99 Es	100 Fm	101 Md	102 No	103 Lr