higher education & training

Department:
Higher Education and Training
REPUBLIC OF SOUTH AFRICA

NATIONAL CERTIFICATE (VOCATIONAL)

PHYSICAL SCIENCE

(Second paper)

NQF LEVEL 3

(10021003)

21 November 2022 (X-paper)
09:00–12:00

Nonprogrammable calculators may be used.

This question paper consists of 11 pages, 1 data sheet, 1 periodic table, 2 information sheets and 1 answer sheet.

541Q2N2221

Copyright reserved

TIME: 3 HOURS
MARKS: 150

INSTRUCTIONS AND INFORMATION

1. Answer all the questions.
2. Read all the questions carefully.
3. Number the answers according to the numbering system used in this question paper.
4. Answer QUESTION 6.1.1 on the ANSWER SHEET (attached). Write your EXAMINATION NUMBER and CENTRE NUMBER in the spaces provided, detach it from the question paper and hand in with the ANSWER BOOK.
5. Start each section on a new page.
6. All final answers must be accurately approximated to TWO decimal places.
7. Cross out any work that you do not want to be marked.
8. Use only a blue or black pen.
9. Write neatly and legibly.

Copyright reserved

SECTION A

QUESTION 1

Give ONE word or term for each of the following descriptions. Write only the answer next to the question number (1.1–1.5) in the ANSWER BOOK.

1.1 The effect caused by the accumulation of carbon dioxide, methane and water in the earth's atmosphere

1.2 A reaction in which more energy is given out than taken in

1.3 A reaction in which two or more reactants combine to form one product

1.4 The deformation or change in shape of a solid due to stress or the force acting on it

1.5 A measure of how easily materials break when under stress

(5 × 1) **[5]**

QUESTION 2

Choose an option from COLUMN B that matches an item in COLUMN A. Write only the letter (A–J) next to the question number (2.1–2.5) in the ANSWER BOOK.

COLUMN A		COLUMN B	
2.1	Activation energy	A	CH_4
2.2	Colourless inert gas	B	2
2.3	Valency of oxygen	C	NH_3
2.4	Pyramidal in shape	D	Energy released during a chemical reaction
2.5	Acidic oxide	E	O_2
		F	6
		G	Energy absorbed during a chemical reaction
		H	SO_2
		I	N_2
		J	Na_2O

(5 × 1) **[5]**

Copyright reserved

QUESTION 3

Indicate whether the following statements are TRUE or FALSE by writing only 'True' or 'False' next to the question number (3.1–3.5) in the ANSWER BOOK.

3.1 Carbon monoxide is regarded as a hazardous gas because it combines readily with oxygen through combustion.

3.2 A liquid with a high vapour pressure has a high boiling point.

3.3 When a liquid is heated, its viscosity decreases because the intermolecular forces are weakened.

3.4 A non-metal oxide dissolves in water to produce an alkaline solution.

3.5 In a laboratory oxygen can be prepared by decomposing hydrogen peroxide.

(5 × 2) **[10]**

QUESTION 4

Various options are given as possible answers to the following questions. Choose the answer and write only the letter (A–D) next to the question number (4.1–4.5) in the ANSWER BOOK.

4.1 Which ONE of the following gases discolours oil paintings containing silver and lead ions?

A CO
B H_2S
C CO_3
D NH_3

4.2 A gas syringe contains a fixed amount of a gas at a volume V_0. The initial pressure and temperature of the gas is P_0 and T_0 respectively.

If the temperature of the gas is increased to 4 T_0 and its pressure is reduced to ½ P_0, what will be the new volume?

A $8\ V_0$
B $6\ V_0$
C $4\ V_0$
D $2\ V_0$

4.3 Which ONE of the following represents one mole of that substance?

A 48 g SO_2
B 28 g CO_2
C 16 g CH_4
D 15 g NO

4.4 Hydrogen reacts with oxygen to produce water according to the following balanced chemical equation:

$$2H_2(g) + O_2(g) \longrightarrow 2H_2O(g)$$

If 20 cm^3 of hydrogen is reacted with 20 cm^3 of oxygen, what will be the TOTAL volume of the gases at the completion of the reaction? Assume that the temperature and pressure remain constant.

A 10 cm^3
B 20 cm^3
C 30 cm^3
D 40 cm^3

4.5 The following statements refer to the boiling point of a liquid.

When a liquid boils its …

(i) temperature stops increasing.
(ii) vapour pressure is at a minimum.
(iii) intermolecular forces are broken.

Which ONE of the following is correct?

A (i) only
B (ii) only
C (ii) and (iii)
D (i) and (iii)

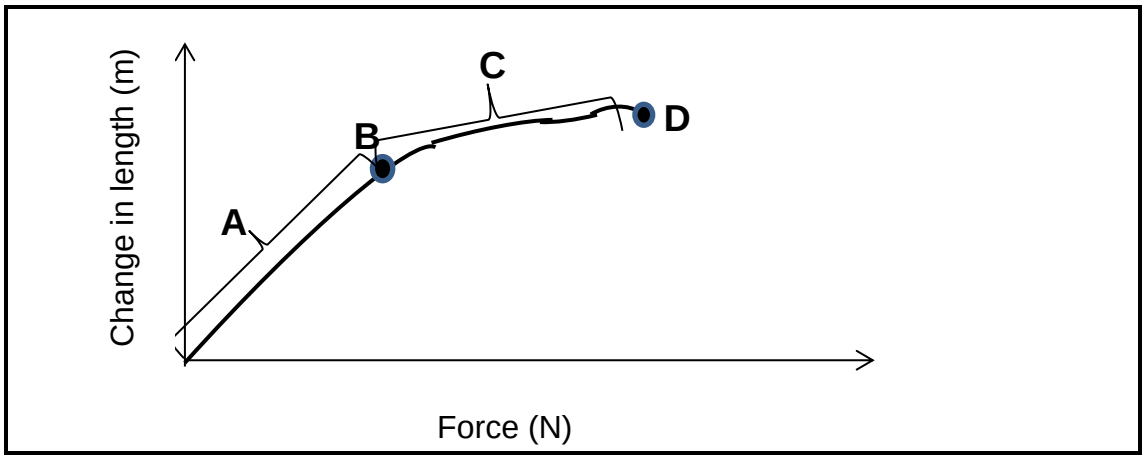
(5 × 3) **[15]**

TOTAL SECTION A: 35

SECTION B

QUESTION 5

5.1 The graph illustrates the change in length of a spring against the force that stretches it.



5.1.1 Define Hooke's law. (2)

5.1.2 Write down the letter (A–D) on the graph that represents:

(a) The plastic region

(b) The elastic limit

(c) The breaking point

(d) The elastic region

(4 × 1) (4)

5.2 One of the steps involved in the formation of MgO(s) is:

$$Mg^{+2} + O^{-2} \longrightarrow MgO(s)$$

5.2.1 State ONE similarity between Mg^{+2} and O^{-2}. (1)

5.2.2 Name the TYPE of bonding that occurs in:

(a) Mg(s)

(b) $O_2(g)$

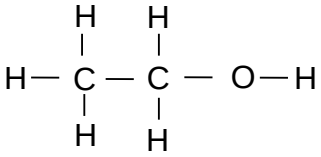
(c) MgO(s)

(3 × 1) (3)

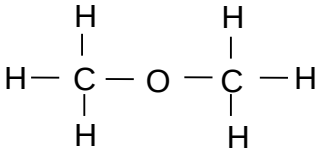
5.2.3 Draw the Lewis diagram for both Mg^{+2} and O^{-2}. (4)

5.2.4 Calculate the oxidation state of Mg in MgO. (1)

5.3 The molecular formula for both ethanol and dimethyl ether is C_2H_6O.



ethanol



dimethyl ether

5.3.1 State TWO factors that affect the boiling point of these liquids. (2)

5.3.2 Does *ethanol* or *dimethyl ether* have the highest boiling point? (1)

5.3.3 Give an explanation for the answer to QUESTION 5.3.2 in terms of the type of intermolecular forces and energy. (3)

[21]

Copyright reserved

QUESTION 6

6.1 A group of learners performed an experiment to establish the relationship between the pressure and volume of an enclosed mass of gas at constant temperature. They tabulated the following results:

VOLUME (cm^3)	PRESSURE (kPa)
40,1	100
26,7	150
20,0	200
16,0	250
13,3	300
11,4	350

6.1.1 Draw a graph of *pressure* versus *volume* on the ANSWER SHEET (attached).

Marks will be allocated for:

- Labels on the axes
- Accuracy of points plotted
- Shape of the graph

Write your EXAMINATION NUMBER and CENTRE NUMBER in the spaces provided, detach it from the question paper and hand in with the ANSWER BOOK. (5)

6.1.2 Write a suitable conclusion for this experiment. (2)

6.1.3 Name the law that was investigated. (1)

6.1.4 Show that the derived unit of *pressure x volume* is the Joule. (3)

6.2 A sample of oxygen gas has a mass of 64 g. The gas is under a pressure of 658 kPa and its temperature is 453 ^oC.

6.2.1 Calculate the volume occupied by the gas. (5)

6.2.2 What is *temperature*? (1)

6.3 The tyre pressure in Tau's truck as shown by the pressure gauge at a filling station is 250 kPa.

What is the absolute pressure in the tyre? (3)

[20]

QUESTION 7

7.1 The metal lid of a glass jar is very tight and cannot be opened. Your supervisor suggests that you use warm water to heat the lid while you keep the jar cool.

7.1.1 Explain why your supervisor's method will work.

7.1.2 What will happen if you heat the glass jar instead of the lid?

(2 × 2) (4)

7.2 A 1 000 dm^3 tank holds 1 000 dm^3 of water. The tank is full to the brim and the temperature of the water is increased from 21 °C to 48 °C. The coefficient of volume expansion of water is $7,5 \times 10^{-5}\ ^oC^{-1}$.

7.2.1 Explain why liquids expand more rapidly than solids. (2)

7.2.2 Calculate the volume of water that will spill out of the tank when the temperature increases from 21 °C to 48 °C. (3)

7.2.3 State the relationship between viscosity and temperature. (2)

7.3 Prof Molepo and his learners performed an experiment to investigate the reactivity of copper, magnesium and zinc. They reacted each of the metals with solutions of copper sulphate, zinc sulphate and iron sulphate.

The following results were obtained:

	Cu(s)	**Mg(s)**	**Zn(s)**
$CuSO_4(aq)$	No reaction	Reaction	Reaction
$FeSO_4(aq)$	No reaction	Reaction	Reaction
$ZnSO_4(aq)$	No reaction	Reaction	No reaction

7.3.1 State TWO observations for the reaction between magnesium metal and the copper sulphate solution. (2)

7.3.2 Zinc metal reacted with the copper sulphate solution.

(a) Write a balanced chemical equation for the reaction. (2)

(b) Write the FORMULA of the most stable reactant. (2)

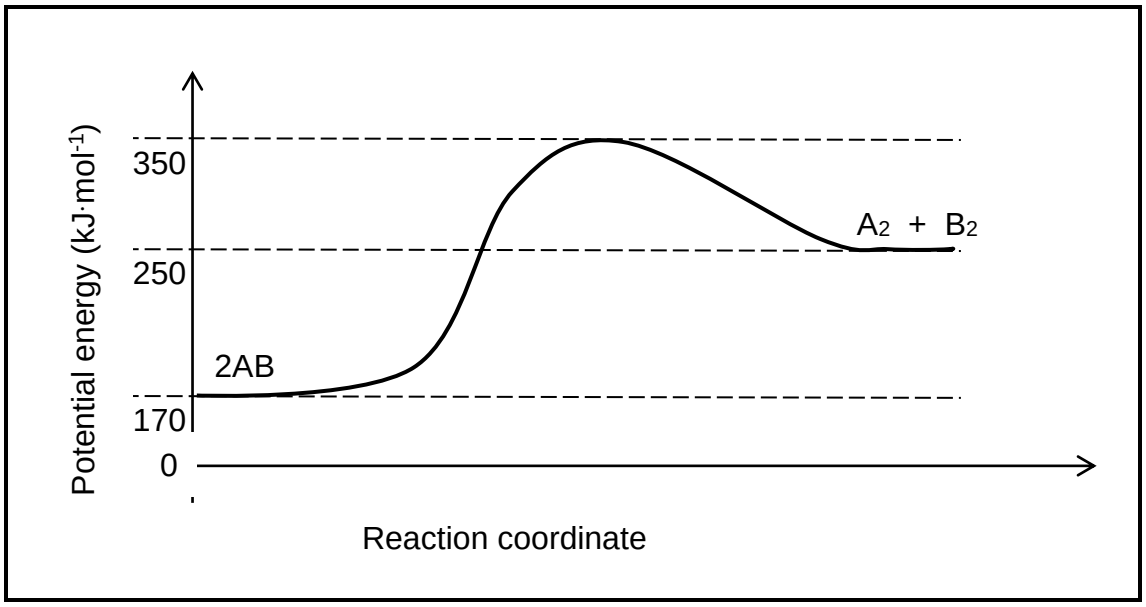
(c) What TYPE of reaction is this? (1)

7.3.3 Arrange the metals from LEAST reactive to MOST reactive. (3)

[21]

QUESTION 8

8.1 The graph illustrates the potential energy changes during the course of a hypothetical reaction. (The graph is not drawn to scale.)



8.1.1 Write the chemical equation for the forward reaction. (2)

8.1.2 Is the forward reaction a COMBINATION, DECOMPOSITION or DISPLACEMENT? (1)

8.1.3 Is the reverse reaction EXOTHERMIC or ENDOTHERMIC? (1)

8.1.4 Give TWO reasons for the answer to QUESTION 8.1.3. (2)

8.1.5 Calculate the activation energy of the reverse reaction. (2)

8.1.6 Determine the enthalpy change for the forward reaction. (2)

8.2 Concentrated sulphuric acid is a strong oxidising agent. It can oxidise copper metal to form copper sulphate, water and sulphur dioxide.

$$Cu(s) + 2H_2SO_4(aq) \longrightarrow CuSO_4(aq) + 2H_2O + SO_2(g)$$

101,6 g of copper metal reacts completely with excess concentrated sulphuric acid.

Calculate:

8.2.1 The number of moles of copper that reacted (3)

8.2.2 The number of moles of $CuSO_4$ produced (1)

8.2.3 The mass of $CuSO_4$ produced (4)

8.2.4 The volume of $SO_2(g)$ produced at STP (4)

Copyright reserved

8.3 Ammonia is a very important ingredient in the manufacture of fertilisers. It is prepared through the Haber process.

$$3H_{2(g)} + N_{2(g)} \rightleftharpoons 2NH_{3(g)} \qquad \Delta H = -46\ kJ{\cdot}mol^{-1}$$

8.3.1 Is the forward reaction a COMBINATION, DECOMPOSITION or DISPLACEMENT? (1)

8.3.2 Write the formula(e) for the product(s) of the reverse reaction. (2)

8.3.3 Calculate the quantity of heat that will be produced if 23,8 g of $NH_3(g)$ is produced. (5)

[30]

QUESTION 9

9.1 The following chemical reaction occurs when lead nitrate is heated strongly:

$$Pb(NO_3)_2 \longrightarrow PbO + O_2 + NO_2$$

9.1.1 What type of reaction is this? (1)

9.1.2 Write a balanced equation for this reaction. (2)

9.1.3 Give suitable names for the products of this reaction. (3)

9.2 Write the formula(e) of the product(s) in the following incomplete chemical equations:

9.2.1 $Ca(s) + O_2(g) \longrightarrow$

9.2.2 $Na(s) + H_2O \longrightarrow$

9.2.3 $F_2(g) + NaBr(aq) \longrightarrow$

9.2.4 $P_4O_{10}(s) + H_2O \longrightarrow$

(4 × 2) (8)

9.3 What type of reaction does QUESTION 9.2.3 represent? (1)

[15]

Copyright reserved

QUESTION 10

10.1 In the chemical industry, a wide range of gases are produced. Some of these gases are referred to as hazardous and others as non-hazardous.

10.1.1 Define the term *hazardous gases*. (2)

10.1.2 Define the term *waste products.* (2)

10.1.3 Name the gas that drastically reduces the ability of haemoglobin to transport oxygen in the blood. (1)

10.2 Name THREE gases that contribute to the formation of acid rain. (3)
[8]

TOTAL SECTION B: 115
GRAND TOTAL: 150

Copyright reserved

DATA SHEET
PHYSICAL SCIENCE L3 (PAPER 2) (CHEMISTRY)

TABLE 1: PHYSICAL CONSTANTS

NAME	SYMBOL	VALUE
Avogadro's constant	N_A	$6{,}02 \times 10^{23}$ mol^{-1}
Molar gas constant	R	8,31 J·K^{-1}·mol^{-1}
Standard pressure	p^{θ}	$1{,}013 \times 10^{5}$ Pa
Molar gas volume at STP	V_m	22,4 dm^3·mol^{-1}
Standard temperature	T^{θ}	273 K

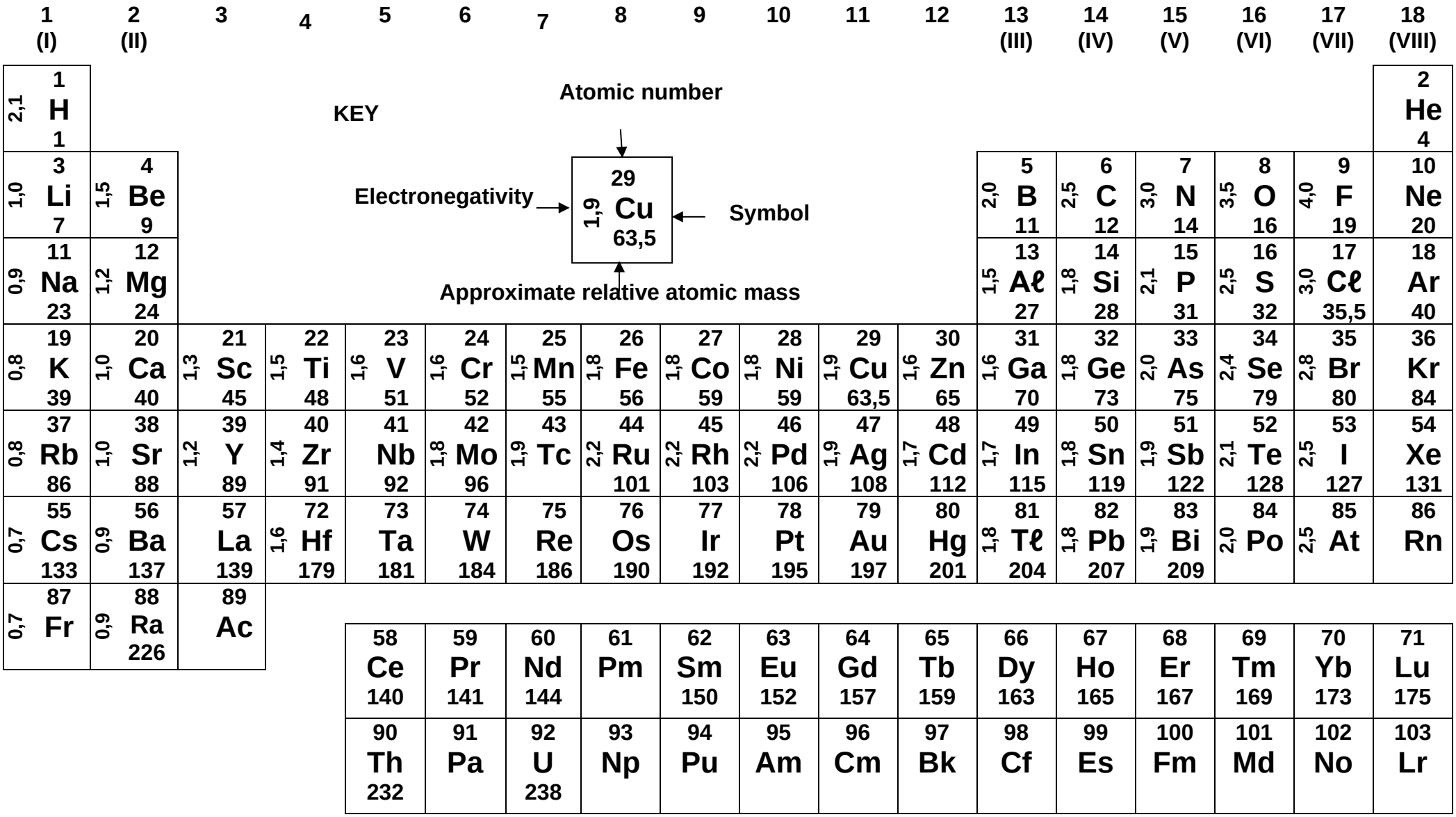
TABLE 2: FORMULAE

$\frac{p_1V_1}{T_1} = \frac{p_2V_2}{T_2}$	$pV = nRT$
$n = \frac{m}{M}$	$n = \frac{N}{N_A}$
$n = \frac{V}{V_m}$	$c = \frac{n}{V}$ OR $c = \frac{m}{MV}$

Copyright reserved

(10021003)

TABLE 3: THE PERIODIC TABLE OF ELEMENTS



Copyright reserved

TABLE 4A: STANDARD REDUCTION POTENTIALS

Halfreaksies/Half-reactions			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
$2H^+ + 2e^-$	**$\rightleftharpoons$**	**$H_2(g)$**	**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

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

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

Copyright reserved

TABLE 4B: STANDARD REDUCTION POTENTIALS

Increasing oxidising ability/*Toenemende oksiderende vermoë* ↓

Half-reactions/*Halfreaksies*	E^{θ} (V)
$Li^+ + e^- \rightleftharpoons Li$	– 3,05
$K^+ + e^- \rightleftharpoons K$	– 2,93
$Cs^+ + e^- \rightleftharpoons Cs$	– 2,92
$Ba^{2+} + 2e^- \rightleftharpoons Ba$	– 2,90
$Sr^{2+} + 2e^- \rightleftharpoons Sr$	– 2,89
$Ca^{2+} + 2e^- \rightleftharpoons Ca$	– 2,87
$Na^+ + e^- \rightleftharpoons Na$	– 2,71
$Mg^{2+} + 2e^- \rightleftharpoons Mg$	– 2,37
$A\ell^{3+} + 3e^- \rightleftharpoons A\ell$	– 1,66
$Mn^{2+} + 2e^- \rightleftharpoons Mn$	– 1,18
$Cr^{2+} + 2e^- \rightleftharpoons Cr$	– 0,91
$2H_2O + 2e^- \rightleftharpoons H_2(g) + 2OH^-$	– 0,83
$Zn^{2+} + 2e^- \rightleftharpoons Zn$	– 0,76
$Cr^{3+} + 3e^- \rightleftharpoons Cr$	– 0,74
$Fe^{2+} + 2e^- \rightleftharpoons Fe$	– 0,44
$Cr^{3+} + e^- \rightleftharpoons Cr^{2+}$	– 0,41
$Cd^{2+} + 2e^- \rightleftharpoons Cd$	– 0,40
$Co^{2+} + 2e^- \rightleftharpoons Co$	– 0,28
$Ni^{2+} + 2e^- \rightleftharpoons Ni$	– 0,27
$Sn^{2+} + 2e^- \rightleftharpoons Sn$	– 0,14
$Pb^{2+} + 2e^- \rightleftharpoons Pb$	– 0,13
$Fe^{3+} + 3e^- \rightleftharpoons Fe$	– 0,06
$2H^+ + 2e^- \rightleftharpoons H_2(g)$	**0,00**
$S + 2H^+ + 2e^- \rightleftharpoons H_2S(g)$	+ 0,14
$Sn^{4+} + 2e^- \rightleftharpoons Sn^{2+}$	+ 0,15
$Cu^{2+} + e^- \rightleftharpoons Cu^+$	+ 0,16
$SO_4^{2-} + 4H^+ + 2e^- \rightleftharpoons SO_2(g) + 2H_2O$	+ 0,17
$Cu^{2+} + 2e^- \rightleftharpoons Cu$	+ 0,34
$2H_2O + O_2 + 4e^- \rightleftharpoons 4OH^-$	+ 0,40
$SO_2 + 4H^+ + 4e^- \rightleftharpoons S + 2H_2O$	+ 0,45
$Cu^+ + e^- \rightleftharpoons Cu$	+ 0,52
$I_2 + 2e^- \rightleftharpoons 2I^-$	+ 0,54
$O_2(g) + 2H^+ + 2e^- \rightleftharpoons H_2O_2$	+ 0,68
$Fe^{3+} + e^- \rightleftharpoons Fe^{2+}$	+ 0,77
$NO_3^- + 2H^+ + e^- \rightleftharpoons NO_2(g) + H_2O$	+ 0,80
$Ag^+ + e^- \rightleftharpoons Ag$	+ 0,80
$Hg^{2+} + 2e^- \rightleftharpoons Hg(\ell)$	+ 0,85
$NO_3^- + 4H^+ + 3e^- \rightleftharpoons NO(g) + 2H_2O$	+ 0,96
$Br_2(\ell) + 2e^- \rightleftharpoons 2Br^-$	+ 1,07
$Pt^{2+} + 2e^- \rightleftharpoons Pt$	+ 1,20
$MnO_2 + 4H^+ + 2e^- \rightleftharpoons Mn^{2+} + 2H_2O$	+ 1,23
$O_2(g) + 4H^+ + 4e^- \rightleftharpoons 2H_2O$	+ 1,23
$Cr_2O_7^{2-} + 14H^+ + 6e^- \rightleftharpoons 2Cr^{3+} + 7H_2O$	+ 1,33
$C\ell_2(g) + 2e^- \rightleftharpoons 2C\ell^-$	+ 1,36
$MnO_4^- + 8H^+ + 5e^- \rightleftharpoons Mn^{2+} + 4H_2O$	+ 1,51
$H_2O_2 + 2H^+ + 2e^- \rightleftharpoons 2H_2O$	+ 1,77
$Co^{3+} + e^- \rightleftharpoons Co^{2+}$	+ 1,81
$F_2(g) + 2e^- \rightleftharpoons 2F^-$	+ 2,87

Increasing reducing ability/*Toenemende reduserende vermoë* ↑

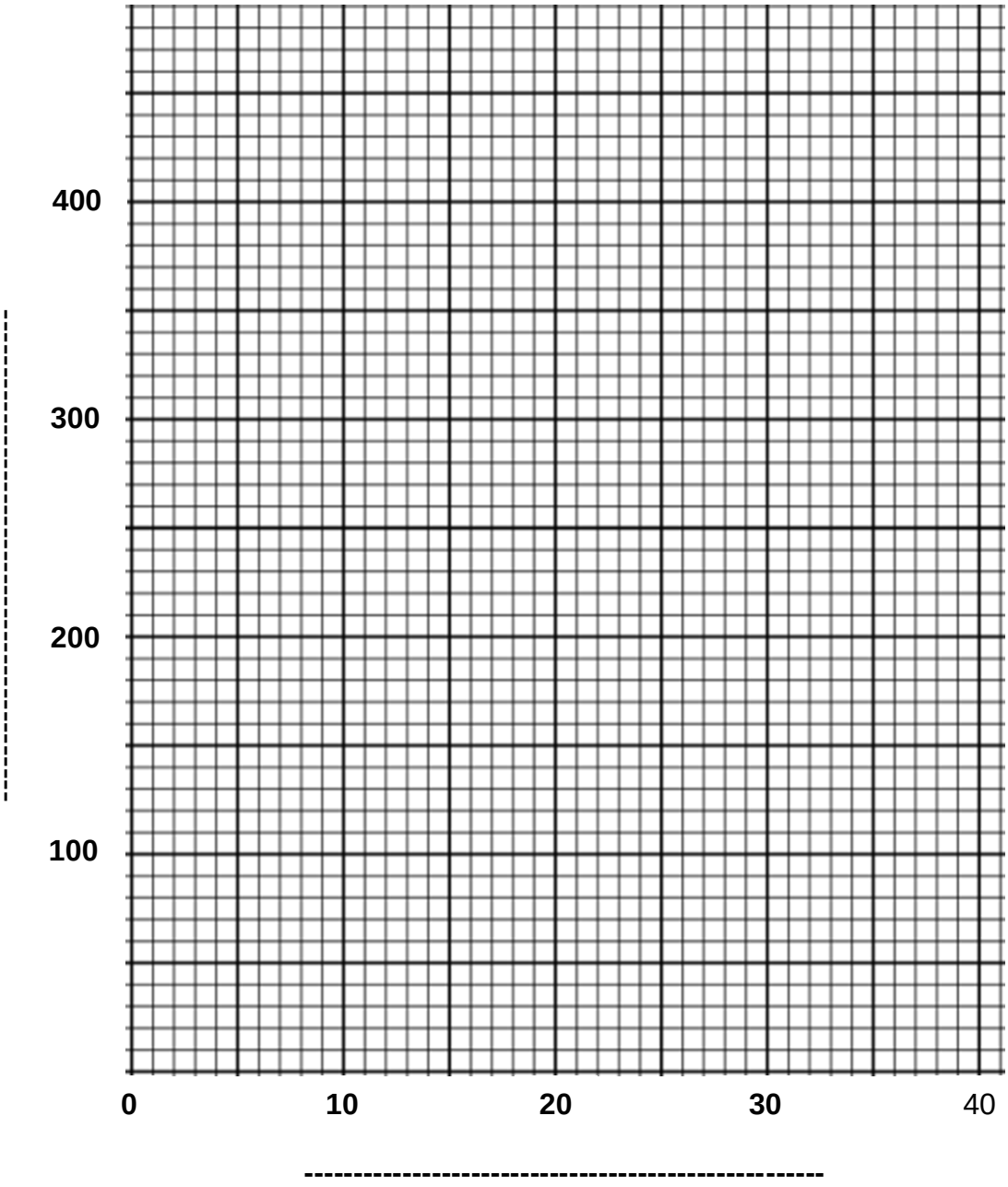
Copyright reserved

ANSWER SHEET

QUESTION 6.1.1

EXAMINATION NUMBER: | | | | | | | | | | | | |

CENTRE NUMBER: | | | | | | | | | | |



Copyright reserved