2018

Yearly Examination

Preliminary Chemistry

General Instructions

Reading time – 5 minutes
Working time – 2 hours

Write using blue or black pen, draw diagrams using pencil

Approved calculators may be used

Write your name on EACH PAGE of this booklet

Detach the Multiple Choice answer sheet and data sheets for your convenience

For questions in Section II, show all relevant working in questions involving calculations

Total marks 75

Section I – 20 marks (pages 3 – 9)

- Attempt questions 1 – 20.
- Allow about 35 minutes for this section.
- Answer on the multiple choice answer sheet at the back of the exam.

Section II – 55 marks (pages 10 – 21)

- Attempt questions 21 – 30
- Allow about 1 hour and 25 minutes for this section.
- Answer in the space provided.

Teacher-in-charge: T. Trotter

Task Weighting: 35%

Student Name: _____________

Trotter (A) □ Naray (B) □ Trotter (C) □ Naray/Crichton (D) □
Trotter (E) □

Section I – 20 marks

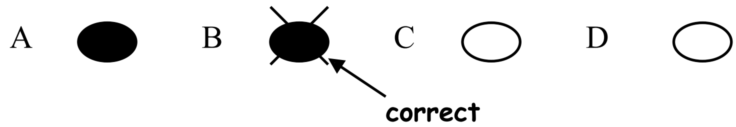
Attempt Questions 1-20
Allow about 35 minutes for this section
Use the multiple-choice answer sheet.

Select the alternative A, B, C or D that best answers the question. Fill in the response oval completely.

Sample: 2 + 4 = (A) 2 (B) 6 (C) 8 (D) 9

If you think you have made a mistake, put a cross through the incorrect answer and fill in the new answer.

If you change your mind and have crossed out what you consider to be the correct answer, then indicate the correct answer by writing the word **correct** and drawing an arrow as follows.



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1. Which of the following is ***not*** conserved in a chemical reaction in a closed system?

(A) total mass

(B) total number of atoms

(C) total number of moles

(D) total charge

2. When solid copper (II) chloride is placed into a non-luminous flame, the colour of the flame changes.

Which of the alternatives identifies the flame colour and the ion that causes the colour?

	Colour	Ion that causes the colour
(A)	red	Cu^{2+}
(B)	red	Cl^{-}
(C)	green	Cu^{2+}
(D)	green	Cl^{-}

3. When a piece of magnesium is placed into a blue Bunsen flame a bright white light is observed as the metal reacts with oxygen gas.

This reaction is:

(A) endothermic with a low activation energy.

(B) endothermic with a high activation energy.

(C) exothermic with a low activation energy.

(D) exothermic with a high activation energy.

4. In the current model of the atom, the number of electrons that can occupy an orbital is:

(A) 2, 8 or 18

(B) 2 or 8

(C) 2 only

(D) 8 only

5. Which of the alternatives below identifies the electron configuration of the cation and anion present in the compound *aluminium chloride*?

	Cation	**Anion**
(A)	$1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^1$	$1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^5$
(B)	$1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^5$	$1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^1$
(C)	$1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6$	$1s^2\ 2s^2\ 2p^6$
(D)	$1s^2\ 2s^2\ 2p^6$	$1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6$

6. A radioisotope (X) undergoes α-decay to produce radioisotope Y.

Radioisotope Y undergoes β-decay to produce actinium-228.

Which of the following identifies radioisotope X?

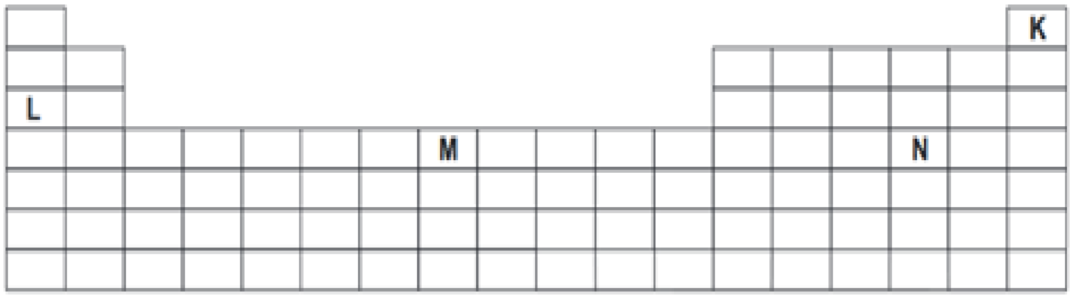
(A) radium-226

(B) uranium-238

(C) palladium-231

(D) thorium-232

7. A section of the periodic table has had the symbols for 4 elements replaced by letters, as shown below.



Which alternative below correctly matches the elements' letters with the blocks to which they belong in the periodic table?

	L	**M**	**N**	**K**
(A)	s	d	p	s
(B)	s	p	d	s
(C)	d	s	p	p
(D)	d	s	p	p

8. The specific heat capacity of substances A and B are given in the table below.

substance	**specific heat capacity ($Jg^{-1}K^{-1}$)**
A	2.121
B	1.433

From the data provided, if 100 kJ of heat energy was added to 1.0g samples of A and B, which of the following statements is true?

(A) The temperature of substance B will increase more than that of A.

(B) The density of substance A will increase more than that of B.

(C) The boiling point of substance A will increase more than that of B.

(D) Substance B will become more reactive than substance A.

9. Which of the following pieces of equipment is always necessary for measuring the rate of a reaction?

(A) an electronic balance

(B) a thermometer

(C) a stopwatch

(D) a stirring rod

10. When a person dives into the ocean, the pressure of gas in their lungs changes from 100kPa to 160kPa.

If their lungs initially held 6.0 L of gas, what volume of gas will be present in the lungs at the increased pressure?

(Assume the temperature of the gas in the lungs remains constant.)

(A) 3.0 L

(B) 3.8 L

(C) 4.5 L

(D) 6.0 L

11. A chemistry student was provided with 250.0mL of 0.84M solution of barium hydroxide and asked to dilute the solution to form 100.0mL of 0.21M barium hydroxide.

Which of the following options concerning the procedure is correct?

	Volume of 0.84M solution required to make the diluted solution (mL)	**Glassware required to make accurately known solution**
(A)	25.0	volumetric flask, pipette
(B)	75.0	volumetric flask, pipette
(C)	25.0	volumetric flask, measuring cylinder
(D)	75.0	volumetric flask, measuring cylinder

12. Which of these equations represents the complete combustion of ethanol (C_2H_5OH)?

(A) $C_2H_5OH(l) + O_2(g) \rightarrow 2C(s) + 3H_2O(l)$

(B) $C_2H_5OH(l) + 2O_2(g) \rightarrow 2CO(g) + 3H_2O(l)$

(C) $C_2H_5OH(l) + 3O_2(g) \rightarrow 2CO_2(g) + 3H_2O(l)$

(D) $C_2H_5OH(l) + 2O_2(g) \rightarrow CO_2(g)\ C(s) + 3H_2O(l)$

13. As you move down the elements in group 7 of the periodic table, the first ionisation energy:

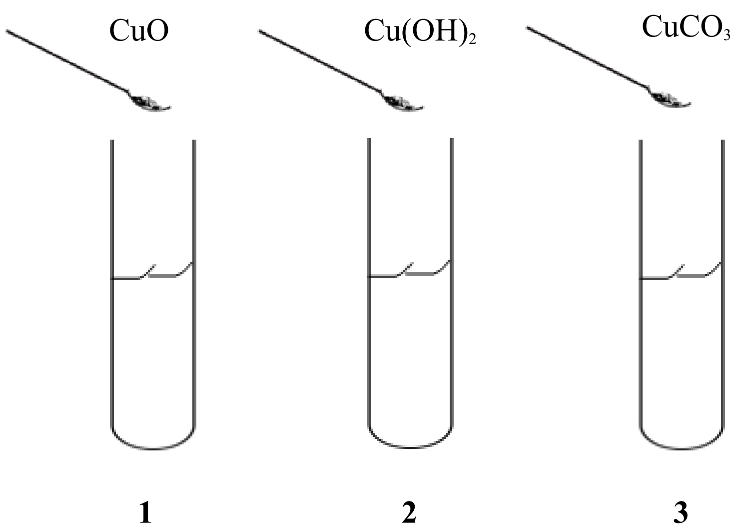
(A) increases and the electronegativity increases.

(B) decreases and the electronegativity increases.

(C) increases and the electronegativity decreases.

(D) decreases and the electronegativity decreases.

14. In the experiment shown below solid CuO, $Cu(OH)_2$ and $CuCO_3$ are added to $HNO_3(aq)$ in three different test tubes.



In which test tube(s) will the solution turn pale blue?

(A) 1

(B) 1 and 2

(C) 2 and 3

(D) 1, 2 and 3

15. Given that $\Delta G = \Delta H - T\Delta S$, identify the correct statement below.

(A) A reaction will always be spontaneous if ΔH is negative and ΔS is positive.

(B) A reaction will always be spontaneous if ΔH is negative and ΔS is negative.

(C) A reaction will always be spontaneous if ΔH is positive and ΔS is positive.

(D) A reaction will always be spontaneous if ΔH is positive and ΔS is negative.

16. Identify the oxidation reaction from the options below.

(A) $2NO_2 \rightarrow N_2O_4$

(B) $CaO + H_2O \rightarrow Ca(OH)_2$

(C) $CaCO_3 \rightarrow CaO + CO_2$

(D) $C + O_2 \rightarrow CO_2$

17. A 1.00 kg sample of liquefied petroleum gas (LPG) contains 600.0 g of propane (C_3H_8) with the remainder being butane (C_4H_{10}).

What mass of this sample of LPG is due to carbon?

(A) 784 g

(B) 792 g

(C) 802 g

(D) 822 g

18. Nitrogen and hydrogen react to produce ammonia according to the equation:

$$3H_2(g) + N_2(g) \leftrightarrow 2NH_3(g) \quad \Delta H = -93 \text{ kJ/mol}$$

Which of the following statements about this reaction is correct?

(A) Breaking the bonds in the reactants releases more energy than is absorbed when the products are formed.

(B) Breaking the bonds in the reactants absorbs more energy than is released when the products are formed.

(C) Breaking the bonds in the reactants absorbs less energy than is released when the products are formed.

(D) Breaking the bonds in the reactants releases less energy than is absorbed when the products are formed.

19. What is the enthalpy change for the reaction:

$$H_2O_2(aq) \rightarrow H_2(g) + O_2(g)$$

given the following reactions and their associated enthalpy changes?

$2H_2O_2(aq) \rightarrow 2H_2O(l) + O_2(g)$ $\Delta H = -200$ kJ/mol

$2H_2O(l) \rightarrow 2H_2(g) + O_2(g)$ $\Delta H = +600$ kJ/mol

(A) +400 kJ/mol

(B) +200 kJ/mol

(C) -200 kJ/mol

(D) -400 kJ/mol

20. Concentrated sulfuric acid reacts with common sugar ($C_{12}O_{22}H_{11}$) in the presence of oxygen to produce a residue of pure carbon as shown below.

$$2C_{12}H_{22}O_{11}(s) + 2H_2SO_4(aq) + O_2(g) \rightarrow 22C(s) + 2CO_2(g) + 24H_2O(l) + 2SO_2(g)$$

What mass of carbon could be produced from the reaction of 5.0g of sugar with excess sulfuric acid and oxygen?

(A) 0.60 g

(B) 0.88 g

(C) 1.9 g

(D) 3.9 g

Section II

55 marks
Attempt Questions 21 – 30
Answer the questions in the spaces provided. Show all relevant working in questions involving calculations.
Allow about 1 hour and 25 minutes for this part

Marks

Question 21 (11 marks)

The symbol for an isotope of phosphorus is:

$$^{31}_{15}P$$

(a) How many protons, neutrons and electrons are present in a neutral atom of this isotope? **1**

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(b) Explain why the relative mass of phosphorus is 30.97 and not 31.0 exactly.

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Question 21 continues on page 10.

Marks

Question 21 (continued)

(c) Phosphorus and nitrogen are in the same group of the periodic table. Both form chlorides.

Some data about their chlorides are shown in the table below.

Element	Chloride Formula	Boiling Point (°C)
Nitrogen	NCl_3	71
Phosphorus	PCl_3	76
	PCl_5	167

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(i) The reaction to form liquid PCl_3 involves heating solid phosphorus in the form of P_4 with chlorine gas. 3

Write a balanced chemical equation for this reaction.

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(ii) Complete the table below.

Formula	Systematic name	Electron dot diagram	Molecular shape
PCl_3			

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(iii) Account for the higher boiling point of PCl_5 compared to PCl_3.

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Question 21 continues on page 11.

Question 21 (continued)

(iv) Provide an explanation, considering the electron configuration of N and P and the concept of valency, for why both nitrogen and phosphorus can form NCl_3 and PCl_3, but only phosphorus is able to form PCl_5.

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Question 22 (3 marks)

Calculate the concentration of nitrate ions present in an 800.0 mL aqueous solution containing 22.5 g of dissolved aluminium nitrate. **3**

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Question 23 (4 marks)

The boiling points of Group 4 and 5 hydrides are shown in the table below.

Group Number	Period Number	Hydride Formula	Boiling Point (°C)
4	2	CH_4	-161
	3	SiH_4	-112
	4	GeH_4	-88
	5	SnH_4	-52
5	2	NH_3	-33
	3	PH_3	-88
	4	AsH_3	-62
	5	SbH_3	-17

Compare the trends in the boiling points of the Group 4 hydrides to those of the Group 5 hydrides as the Period number increases in each group, and explain any differences. **4**

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Question 24 (4 marks) **Marks**

A chemist heats three substances; magnesium, copper (II) carbonate and ethane (C_2H_6) gas (one at a time) in a blue Bunsen flame.

All three substances react, two of them with oxygen in the air.

(a) Write a balanced chemical equation for each of the three reactions. **3**

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(b) Only the reaction of copper (II) carbonate is endothermic.

Use the appropriate chemical terminology to identify why the heat of the Bunsen flame is required for the other two reactions.

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Question 25 (7 marks)

The equation for the combustion of methane is:

$CH_4(g) + 2O_2(g) \rightarrow CO_2(g) + 2H_2O(l)$ $\Delta H_c = -890$ kJ/mol

(a) (i) Write the equation for the reaction that corresponds to the standard enthalpy of formation of methane. **1**

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(ii) The standard enthalpy of formation of methane cannot be measured experimentally, so it must be calculated using Hess's Law. **3**

Use the information above, and the information in the table below to calculate the standard enthalpy of formation of methane.

Reaction	Standard enthalpy of formation (ΔH_f^0) (kJ/mol)
$C(s) + O_2(g) \rightarrow CO_2(g)$	-395
$H_2(g) + \frac{1}{2}O_2(g) \rightarrow H_2O(l)$	-286

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(b) The value of the entropy change for the combustion of methane is -242 $JK^{-1}mol^{-1}$.

Explain why a negative entropy change is consistent with the equation for the combustion reaction.

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(c) Use the Gibbs free energy equation to determine whether the combustion of
methane will be spontaneous at 300 K.

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Question 26 (4 marks)

A student used the following apparatus to decompose a small sample of an oxide of copper. The purpose of the natural gas from the outlet is to prevent any copper that forms from oxidising back into a copper ion.

The products of the decomposition are metallic copper and oxygen.

The data from the experiment are shown below.

Mass of empty test tube (g)	30.43
Mass of test tube and copper oxide powder before heating (g)	32.73
Mass of test tube and residue after heating for 1 minute (g)	32.58
Mass of test tube and residue after heating for 2 minute (g)	32.34
Mass of test tube and residue after heating for 3 minute (g)	32.23
Mass of test tube and residue after heating for 4 minute (g)	32.23

(a) Use the data provided to determine the empirical formula of the oxide decomposed in the investigation. **3**

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(b) Suggest a reason for measuring the mass of the test tube and residue after each minute of heating.

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Marks

Question 27 (7 marks)

Consider the following redox pairs and their reduction potentials (E^0 values):

Zr^{4+}/Zr	- 1.53 V
Ga^{3+}/Ga	- 0.53 V
Au^{+}/Au	+ 1.68 V
V^{2+}/V	- 1.18 V
Pt^{2+}/Pt	+ 1.20 V

(a) Identify the species which is the: **2**

(i) strongest oxidant ……………………………………………………….

(ii) strongest reductant ……………………………………………………...

(b) A chemist wants to determine the cell voltage of a Galvanic cell involving the Ni^{2+}/Ni and Ag^{+}/Ag redox pairs.

Draw a labelled diagram of a galvanic cell that could be constructed to achieve this. **3**

(c) Use the standard half-cell potentials on the Data Sheet to calculate the voltage produced by the cell. **2**

Show all working and include the overall net ionic equation for the reaction.

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Marks

Question 28 (4 marks)

Energy is transferred when a substance dissolves in water.

Write a safe method that could be used to determine the enthalpy of solution of an ionic compound, specifying the data to be collected and any necessary calculations. **4**

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Marks

Question 29 (5 marks)

Nitrogen gas can be prepared by passing ammonia gas over solid copper (II) oxide at high temperatures. The reaction also forms solid copper and water vapour.

In an experiment, 39.40 g of NH_3 is placed in a container with 192.50 g of copper (II) oxide at high temperature.

What volume of nitrogen gas (collected at 25°C and 100kPa) will actually be formed if the process is only 70% efficient? **5**

Show all working, including a relevant balanced chemical equation with your answer.

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Question 30 (6 marks)

A student carried out four experiments involving magnesium and hydrochloric acid under various reaction conditions, shown in the table below.

The results they obtained in THREE of these experiments are represented by the three lines shown in the graph below.

Reaction conditions	Form of Mg(s)	Acid concentration (M)	Temperature (°C)
1	4 x 1cm strips	5	25

2	2 x 1cm strips	1	50
3	powdered	1	25
4	2 x 1cm strips	1	25

Question 30 continues on page 20

Question 30 (continued) **Marks**

Add a line for reaction conditions 4 to the graph, and explain the trends shown by the results of the experiment using collision theory. **6**

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Chemistry

FORMULAE SHEET

$n = \frac{m}{MM}$	$c = \frac{n}{V}$	$PV = nRT$
$q = mc\Delta T$	$\Delta G° = \Delta H° - T\Delta S°$	$pH = -\log_{10}[H^+]$
$pK_a = -\log_{10}[K_a]$	$A = \varepsilon lc = \log_{10}\frac{I_o}{I}$	

Avogadro constant, N_A .... 6.022×10^{23} mol^{-1}

Volume of 1 mole ideal gas: at 100 kPa and
at 0°C (273.15 K) .... 22.71 L
at 25°C (298.15 K) .... 24.79 L

Gas constant .... 8.314 J mol^{-1} K^{-1}

Ionisation constant for water at 25°C (298.15 K), K_w .... 1.0×10^{-14}

Specific heat capacity of water .... 4.18×10^3 J kg^{-1} K^{-1}

DATA SHEET

Solubility constants at 25°C

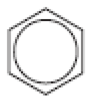
Compound	K_{sp}	*Compound*	K_{sp}
Barium carbonate	2.58×10^{-9}	Lead(II) bromide	6.60×10^{-6}
Barium hydroxide	2.55×10^{-4}	Lead(II) chloride	1.70×10^{-5}
Barium phosphate	1.3×10^{-29}	Lead(II) iodide	9.8×10^{-9}
Barium sulfate	1.08×10^{-10}	Lead(II) carbonate	7.40×10^{-14}
Calcium carbonate	3.36×10^{-9}	Lead(II) hydroxide	1.43×10^{-15}
Calcium hydroxide	5.02×10^{-6}	Lead(II) phosphate	8.0×10^{-43}
Calcium phosphate	2.07×10^{-29}	Lead(II) sulfate	2.53×10^{-8}
Calcium sulfate	4.93×10^{-5}	Magnesium carbonate	6.82×10^{-6}
Copper(II) carbonate	1.4×10^{-10}	Magnesium hydroxide	5.61×10^{-12}
Copper(II) hydroxide	2.2×10^{-20}	Magnesium phosphate	1.04×10^{-24}
Copper(II) phosphate	1.40×10^{-37}	Silver bromide	5.35×10^{-13}
Iron(II) carbonate	3.13×10^{-11}	Silver chloride	1.77×10^{-10}
Iron(II) hydroxide	4.87×10^{-17}	Silver carbonate	8.46×10^{-12}
Iron(III) hydroxide	2.79×10^{-39}	Silver hydroxide	2.0×10^{-8}
Iron(III) phosphate	9.91×10^{-16}	Silver iodide	8.52×10^{-17}
		Silver phosphate	8.89×10^{-17}
		Silver sulfate	1.20×10^{-5}

Aylward and Findlay, *SI Chemical Data* (5th Edition) is the principal source of data for this examination paper. Some data may have been modified for examination purposes.

Infrared absorption data

Bond	Wavenumber/cm^{-1}
N—H (amines)	3300–3500
O—H (alcohols)	3230–3550 (broad)
C—H	2850–3300
O—H (acids)	2500–3000 (very broad)
C≡N	2220–2260
C=O	1680–1750
C=C	1620–1680
C—O	1000–1300
C—C	750–1100

^{13}C NMR chemical shift data

Type of carbon		δ/ppm
—C—C—		5–40
R—C—Cl or Br		10–70
R—C(=O)—C—		20–50
R—C—N<		25–60
—C—O—	alcohols, ethers or esters	50–90
>C=C<		90–150
R—C≡N		110–125
		110–160
R—C(=O)—	esters or acids	160–185
R—C(=O)—	aldehydes or ketones	190–220

UV absorption

(This is not a definitive list and is approximate.)

Chromophore	λ_{max} (nm)
C—H	122
C—C	135
C=C	162

Chromophore	λ_{max} (nm)
C≡C	173 178 196 222
C—Cl	173
C—Br	208

Some standard potentials

$K^+ + e^-$	$\rightleftharpoons$	$K(s)$	–2.94 V
$Ba^{2+} + 2e^-$	$\rightleftharpoons$	$Ba(s)$	–2.91 V
$Ca^{2+} + 2e^-$	$\rightleftharpoons$	$Ca(s)$	–2.87 V
$Na^+ + e^-$	$\rightleftharpoons$	$Na(s)$	–2.71 V
$Mg^{2+} + 2e^-$	$\rightleftharpoons$	$Mg(s)$	–2.36 V
$Al^{3+} + 3e^-$	$\rightleftharpoons$	$Al(s)$	–1.68 V
$Mn^{2+} + 2e^-$	$\rightleftharpoons$	$Mn(s)$	–1.18 V
$H_2O + e^-$	$\rightleftharpoons$	$\frac{1}{2}H_2(g) + OH^-$	–0.83 V
$Zn^{2+} + 2e^-$	$\rightleftharpoons$	$Zn(s)$	–0.76 V
$Fe^{2+} + 2e^-$	$\rightleftharpoons$	$Fe(s)$	–0.44 V
$Ni^{2+} + 2e^-$	$\rightleftharpoons$	$Ni(s)$	–0.24 V
$Sn^{2+} + 2e^-$	$\rightleftharpoons$	$Sn(s)$	–0.14 V
$Pb^{2+} + 2e^-$	$\rightleftharpoons$	$Pb(s)$	–0.13 V
$H^+ + e^-$	$\rightleftharpoons$	$\frac{1}{2}H_2(g)$	0.00 V
$SO_4^{2-} + 4H^+ + 2e^-$	$\rightleftharpoons$	$SO_2(aq) + 2H_2O$	0.16 V
$Cu^{2+} + 2e^-$	$\rightleftharpoons$	$Cu(s)$	0.34 V
$\frac{1}{2}O_2(g) + H_2O + 2e^-$	$\rightleftharpoons$	$2OH^-$	0.40 V
$Cu^+ + e^-$	$\rightleftharpoons$	$Cu(s)$	0.52 V
$\frac{1}{2}I_2(s) + e^-$	$\rightleftharpoons$	I^-	0.54 V
$\frac{1}{2}I_2(aq) + e^-$	$\rightleftharpoons$	I^-	0.62 V
$Fe^{3+} + e^-$	$\rightleftharpoons$	Fe^{2+}	0.77 V
$Ag^+ + e^-$	$\rightleftharpoons$	$Ag(s)$	0.80 V
$\frac{1}{2}Br_2(l) + e^-$	$\rightleftharpoons$	Br^-	1.08 V
$\frac{1}{2}Br_2(aq) + e^-$	$\rightleftharpoons$	Br^-	1.10 V
$\frac{1}{2}O_2(g) + 2H^+ + 2e^-$	$\rightleftharpoons$	H_2O	1.23 V
$\frac{1}{2}Cl_2(g) + e^-$	$\rightleftharpoons$	Cl^-	1.36 V
$\frac{1}{2}Cr_2O_7^{2-} + 7H^+ + 3e^-$	$\rightleftharpoons$	$Cr^{3+} + \frac{7}{2}H_2O$	1.36 V
$\frac{1}{2}Cl_2(aq) + e^-$	$\rightleftharpoons$	Cl^-	1.40 V
$MnO_4^- + 8H^+ + 5e^-$	$\rightleftharpoons$	$Mn^{2+} + 4H_2O$	1.51 V
$\frac{1}{2}F_2(g) + e^-$	$\rightleftharpoons$	F^-	2.89 V

PERIODIC TABLE OF THE ELEMENTS

KEY

Atomic Number	79
Symbol	Au
Standard Atomic Weight	197.0
Name	Gold

1 H 1.008 Hydrogen																	2 He 4.003 Helium
3 Li 6.941 Lithium	4 Be 9.012 Beryllium											5 B 10.81 Boron	6 C 12.01 Carbon	7 N 14.01 Nitrogen	8 O 16.00 Oxygen	9 F 19.00 Fluorine	10 Ne 20.18 Neon
11 Na 22.99 Sodium	12 Mg 24.31 Magnesium											13 Al 26.98 Aluminium	14 Si 28.09 Silicon	15 P 30.97 Phosphorus	16 S 32.07 Sulfur	17 Cl 35.45 Chlorine	18 Ar 39.95 Argon
19 K 39.10 Potassium	20 Ca 40.08 Calcium	21 Sc 44.96 Scandium	22 Ti 47.87 Titanium	23 V 50.94 Vanadium	24 Cr 52.00 Chromium	25 Mn 54.94 Manganese	26 Fe 55.85 Iron	27 Co 58.93 Cobalt	28 Ni 58.69 Nickel	29 Cu 63.55 Copper	30 Zn 65.38 Zinc	31 Ga 69.72 Gallium	32 Ge 72.64 Germanium	33 As 74.92 Arsenic	34 Se 78.96 Selenium	35 Br 79.90 Bromine	36 Kr 83.80 Krypton
37 Rb 85.47 Rubidium	38 Sr 87.61 Strontium	39 Y 88.91 Yttrium	40 Zr 91.22 Zirconium	41 Nb 92.91 Niobium	42 Mo 95.96 Molybdenum	43 Tc Technetium	44 Ru 101.1 Ruthenium	45 Rh 102.9 Rhodium	46 Pd 106.4 Palladium	47 Ag 107.9 Silver	48 Cd 112.4 Cadmium	49 In 114.8 Indium	50 Sn 118.7 Tin	51 Sb 121.8 Antimony	52 Te 127.6 Tellurium	53 I 126.9 Iodine	54 Xe 131.3 Xenon
55 Cs 132.9 Caesium	56 Ba 137.3 Barium	57–71 Lanthanoids	72 Hf 178.5 Hafnium	73 Ta 180.9 Tantalum	74 W 183.9 Tungsten	75 Re 186.2 Rhenium	76 Os 190.2 Osmium	77 Ir 192.2 Iridium	78 Pt 195.1 Platinum	79 Au 197.0 Gold	80 Hg 200.6 Mercury	81 Tl 204.4 Thallium	82 Pb 207.2 Lead	83 Bi 209.0 Bismuth	84 Po Polonium	85 At Astatine	86 Rn Radon
87 Fr Francium	88 Ra Radium	89–103 Actinoids	104 Rf Rutherfordium	105 Db Dubnium	106 Sg Seaborgium	107 Bh Bohrium	108 Hs Hassium	109 Mt Meitnerium	110 Ds Darmstadtium	111 Rg Roentgenium	112 Cn Copernicium	113 Nh Nihonium	114 Fl Flerovium	115 Mc Moscovium	116 Lv Livermorium	117 Ts Tennessine	118 Og Oganesson

Lanthanoids

57 La 138.9 Lanthanum	58 Ce 140.1 Cerium	59 Pr 140.9 Praseodymium	60 Nd 144.2 Neodymium	61 Pm Promethium	62 Sm 150.4 Samarium	63 Eu 152.0 Europium	64 Gd 157.3 Gadolinium	65 Tb 158.9 Terbium	66 Dy 162.5 Dysprosium	67 Ho 164.9 Holmium	68 Er 167.3 Erbium	69 Tm 168.9 Thulium	70 Yb 173.1 Ytterbium	71 Lu 175.0 Lutetium

Actinoids

89 Ac Actinium	90 Th 232.0 Thorium	91 Pa 231.0 Protactinium	92 U 238.0 Uranium	93 Np Neptunium	94 Pu Plutonium	95 Am Americium	96 Cm Curium	97 Bk Berkelium	98 Cf Californium	99 Es Einsteinium	100 Fm Fermium	101 Md Mendelevium	102 No Nobelium	103 Lr Lawrencium

Standard atomic weights are abridged to four significant figures.

Elements with no reported values in the table have no stable nuclides.

Information on elements with atomic numbers 113 and above is sourced from the International Union of Pure and Applied Chemistry Periodic Table of the Elements (November 2016 version).

The International Union of Pure and Applied Chemistry Periodic Table of the Elements (February 2010 version) is the principal source of all other data. Some data may have been modified.

BACK OF MULTIPLE CHOICE ANSWER SHEET

Section I - Answer Sheet

Use of the multiple-choice answer sheet.

Select the alternative A, B, C or D that best answers the question and fill in the response oval completely.

Sample $2 + 4 =$ (A) 2 (B) 6 (C) 8 (D) 9

(A) ○ (B) ● (C) ○ (D) ○

If you think you have made a mistake, put a cross through the incorrect answer and fill in the new answer.

(A) ● (B) ☒ (C) ○ (D) ○

If you change your mind and have crossed out what you consider to be the correct answer, then indicate this by writing the word correct and drawing an arrow as follows:

correct

(A) ☒ (B) ☒ (C) ○ (D) ○

1.	(A) ○	(B) ○	(C) ○	(D) ○
2.	(A) ○	(B) ○	(C) ○	(D) ○
3.	(A) ○	(B) ○	(C) ○	(D) ○
4.	(A) ○	(B) ○	(C) ○	(D) ○
5.	(A) ○	(B) ○	(C) ○	(D) ○
6.	(A) ○	(B) ○	(C) ○	(D) ○
7.	(A) ○	(B) ○	(C) ○	(D) ○
8.	(A) ○	(B) ○	(C) ○	(D) ○
9.	(A) ○	(B) ○	(C) ○	(D) ○
10.	(A) ○	(B) ○	(C) ○	(D) ○
11.	(A) ○	(B) ○	(C) ○	(D) ○
12.	(A) ○	(B) ○	(C) ○	(D) ○
13.	(A) ○	(B) ○	(C) ○	(D) ○
14.	(A) ○	(B) ○	(C) ○	(D) ○
15.	(A) ○	(B) ○	(C) ○	(D) ○
16.	(A) ○	(B) ○	(C) ○	(D) ○
17.	(A) ○	(B) ○	(C) ○	(D) ○
18.	(A) ○	(B) ○	(C) ○	(D) ○
19.	(A) ○	(B) ○	(C) ○	(D) ○
20.	(A) ○	(B) ○	(C) ○	(D) ○