Rewarding Learning

ADVANCED SUBSIDIARY (AS)
General Certificate of Education
2016

Centre Number

Candidate Number

Chemistry

Assessment Unit AS 1
assessing
Basic Concepts in Physical and Inorganic Chemistry

AC112

[AC112]

TUESDAY 14 JUNE, AFTERNOON

TIME

1 hour 30 minutes.

INSTRUCTIONS TO CANDIDATES

Write your Centre Number and Candidate Number in the spaces provided at the top of this page.
Answer **all eighteen** questions.
Answer **all ten** questions in **Section A**. Record your answers by marking the appropriate letter on the answer sheet provided. Use only the spaces numbered 1 to 10. Keep in sequence when answering.
Answer **all eight** questions in **Section B**. **You must answer the questions in the spaces provided.**
Do not write outside the boxed area on each page or on blank pages.
Complete in blue or black ink only. **Do not write with a gel pen.**

INFORMATION FOR CANDIDATES

The total mark for this paper is 100.
Quality of written communication will be assessed in Question **12(a)**.
In Section A all questions carry equal marks, i.e. **two** marks for each question.
In Section B the figures in brackets printed down the right-hand side of pages indicate the marks awarded to each question or part question.
A Periodic Table of Elements, containing some data, is included in this question paper.

Section A

For each of the following questions only **one** of the lettered responses (A–D) is correct.

Select the correct response in each case and mark its code letter by connecting the dots as illustrated on the answer sheet.

1 Which one of the following shows how many electron pairs can be accommodated in the third energy level, n = 3, of an atom?

A 3

B 6

C 9

D 18

2 Which one of the following molecules contains a total of six bonding electrons?

A C_2H_4

B CO_2

C NH_3

D SF_6

3 Which one of the following molecules is **not** polar?

A $CHCl_3$

B CH_3OCH_3

C CO_2

D SO_2

4 An element X has the following ionisation energies:

	1st	**2nd**	**3rd**	**4th**	**5th**	**6th**
ionisation energy/ kJ mol^{-1}	738	1451	7733	10543	13630	18020

Which one of the following is the formula of the chloride of X?

A XCl

B XCl_2

C XCl_3

D XCl_4

5 A salt gives a pink flame in a flame test when observed through cobalt glass.
A solution of the salt gives a cream precipitate when added to acidified silver nitrate solution. Which one of the following is the salt?

A Potassium bromide

B Potassium chloride

C Sodium bromide

D Sodium chloride

6 Which one of the following indicators is **not** suitable for the acid-base titration shown?

	0.1 M acid	**0.2 M base**	**indicator**
A	ethanoic acid	ammonia solution	phenolphthalein
B	ethanoic acid	sodium hydroxide solution	phenolphthalein
C	hydrochloric acid	ammonia solution	methyl orange
D	hydrochloric acid	sodium hydroxide solution	methyl orange

7 Iron can be extracted from iron(III) oxide using carbon according to the following equation:

$$2Fe_2O_3 + 3C \rightarrow 4Fe + 3CO_2$$

Which one of the following is the maximum mass of iron that can be extracted from a mixture of 150.0 tonnes of iron(III) oxide and 15.0 tonnes of carbon?

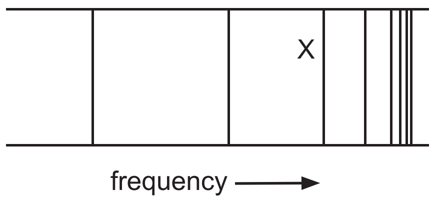
A 26.3 tonnes

B 52.6 tonnes

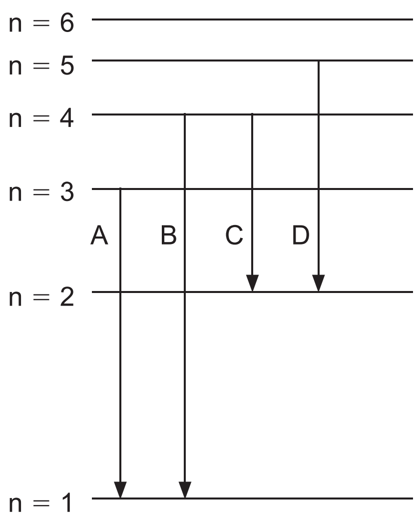
C 93.3 tonnes

D 105.3 tonnes

8 The atomic emission spectrum of hydrogen for the visible region is shown below:



Which one of the labelled transitions is responsible for line X in the spectrum?



9 A sample of hydrated sodium sulfate contains 56%, by mass, of water. What is the formula of the hydrated sodium sulfate?

A $Na_2SO_4.H_2O$

B $Na_2SO_4.6H_2O$

C $Na_2SO_4.10H_2O$

D $Na_2SO_4.12H_2O$

10 A cup of coffee contains 500 mg of caffeine which has the chemical formula $C_8H_{10}N_4O_2$. Which one of the following is the number of nitrogen atoms present in this amount of caffeine?

A 1.55×10^{21}

B 6.21×10^{21}

C 1.55×10^{24}

D 6.21×10^{24}

[Turn over

Section B

Answer **all eight** questions in this section.

11 Complete the following table for the ions of three elements, A, B and C.

ion	atomic number	electronic structure of ion
A^{3+}	5	
B^{-}		$1s^2 2s^2 2p^6 3s^2 3p^6 3d^{10} 4s^2 4p^6$
C^{2-}	16	

[3]

12 The 2010 Nobel Prize for Physics was awarded for the discovery of a new material called graphene. It consists of a single layer of carbon atoms obtained from graphite.

(a) Describe the structure and bonding of graphite. Include an explanation why graphite can conduct electricity.

____

____

____

____

____

____

____

____ [4]

Quality of written communication [2]

(b) Explain why graphene, like graphite, has a high melting point.

____

____ [2]

13 In 1937 the American scientists Taylor and Crist investigated the decomposition of gaseous hydrogen iodide. The hydrogen iodide was heated in a sealed quartz tube.

$$2HI(g) \rightleftharpoons H_2(g) + I_2(g)$$

(a) Taylor and Crist were able to measure the progress of the decomposition by measuring colour intensity.

(i) State the colour of iodine gas.

______________________________ [1]

(ii) Suggest what would be observed if this experiment was to be repeated with samples of hydrogen chloride and hydrogen bromide.

____

______________________________ [2]

(iii) Explain the difference in observations between hydrogen chloride and hydrogen bromide.

____

______________________________ [1]

(b) Hydrogen iodide dissolves in water to form hydriodic acid which is a strong acid.

(i) Explain whether hydriodic acid is a stronger or weaker acid than hydrochloric acid.

____

______________________________ [2]

(ii) Suggest an equation for the reaction between sodium carbonate and hydriodic acid.

______________________________ [2]

10120

(c) The boiling points of the hydrogen halides at atmospheric pressure are shown below:

hydrogen halide	boiling point/°C
HF	19.9
HCl	−85.0
HBr	−66.7
HI	−35.4

Explain why hydrogen iodide has a higher boiling point than hydrogen chloride.

____

____

____ [2]

14 The hydrogen atom contains one electron and is difficult to place in a particular group in the Periodic Table. It could be in either Group I or Group VII.

(a) Suggest reasons, with reference to electron structure, why hydrogen could be placed in Group I or Group VII.

(i) Group I ____

____ [1]

(ii) Group VII ____

____ [1]

(b) Hydrogen, like the halogens, exists as diatomic molecules. However, it is much less reactive because it has a stronger covalent bond than any of the halogens.

(i) State the trend in bond energy of the halogen molecules.

____

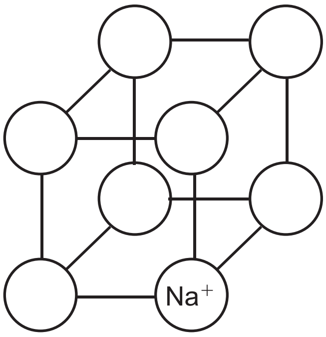
____ [2]

(ii) Suggest why hydrogen has a higher bond energy than any of the halogen molecules.

____ [1]

(c) Hydrogen reacts with sodium to form sodium hydride. Ions are formed in a similar manner to sodium and chloride ions.

(i) Complete the following diagram to show how the ions are arranged in a sodium chloride lattice.



Sodium chloride

[1]

(ii) Draw a dot and cross diagram, using outer electrons only, to show the reaction between sodium and hydrogen atoms to form sodium hydride.

[3]

[Turn over

(iii) Sodium hydride is a powerful reducing agent and will react with water to form sodium hydroxide and hydrogen. Write an equation for this reaction.

____ [1]

(iv) 0.44 g of sodium hydride is reacted with 75 cm^3 of water.

Calculate the number of moles of sodium hydride.

____

Calculate the number of moles of sodium hydroxide formed.

____

Calculate the molarity of the sodium hydroxide solution.

____ [3]

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(Questions continue overleaf)

15 Chlorine has many industrial uses, particularly as a bleaching agent. It is used to bleach wood pulp in paper manufacture and to remove ink from paper which is to be recycled.

(a) Chlorine has two stable isotopes ^{35}Cl and ^{37}Cl present in nature in the following proportions.

isotope	abundance
^{35}Cl	75.78%
^{37}Cl	24.22%

Calculate the relative atomic mass of chlorine to **two** decimal places.

____

____

______________________________ [2]

(b) Household bleach contains sodium chlorate(I) rather than molecular chlorine. Sodium chlorate(I) can be made by reacting sodium hydroxide with chlorine gas in a disproportionation reaction.

(i) Explain what is meant by a **disproportionation** reaction.

____

______________________________ [1]

(ii) Write an equation for the reaction between chlorine and sodium hydroxide to form sodium chlorate(I) and state the conditions for the formation of sodium chlorate(I).

equation ______________________________ [2]

conditions ______________________________ [1]

(iii) Explain, in terms of bonding, why sodium chlorate(I) has a higher boiling point than chlorine.

____

____ [2]

(c) Chlorine can form a number of chlorine oxides. Complete the table below giving the oxidation number of chlorine in each chlorine oxide.

formula of chlorine oxide	**oxidation number of chlorine**
Cl_2O	
ClO_2	
Cl_2O_7	

[3]

16 Strontium carbonate is commonly used in fireworks and flares as it gives a red flame colour. It contains strontium ions which are isoelectronic with krypton atoms.

(a) **(i)** Suggest the formula and electronic configuration for the strontium ion.

____

____ [2]

(ii) Suggest the meaning of the term **isoelectronic**.

____

____ [1]

(b) The red light emitted by one mole of strontium ions has an energy of 171.09 kJ.

(i) Calculate the energy, in joules, emitted by one ion of strontium.

____

____ [2]

(ii) Calculate the frequency of this light.

____ [1]

(iii) Explain, using electronic transitions, why strontium ions give a red colour in fireworks.

____

____

____ [3]

(c) $60\,cm^3$ of $2.0\,mol\,dm^{-3}$ hydrochloric acid was added to 2.56 g of a sample from the firework. The resultant solution was filtered and made up to $500\,cm^3$ with deionised water. $25.0\,cm^3$ of this solution was titrated against $0.2\,mol\,dm^{-3}$ sodium hydroxide. The following results were obtained:

	initial burette reading/cm³	**final burette reading/cm³**	**titre/cm³**
rough	0.0	24.9	24.9
1st accurate	24.9	49.5	24.6
2nd accurate	0.0	24.5	24.5

The reactions which occur are:

$$SrCO_3 + 2HCl \rightarrow SrCl_2 + CO_2 + H_2O$$

$$NaOH + HCl \rightarrow NaCl + H_2O$$

(i) Calculate the total number of moles of hydrochloric acid added.

____

(ii) Calculate the number of moles of sodium hydroxide reacted.

____

(iii) How many moles of hydrochloric acid are there in $500\,cm^3$ of the solution?

____

(iv) Calculate the number of moles of hydrochloric acid that reacted with the strontium carbonate.

____

(v) Calculate the mass of strontium carbonate in the sample.

____

(vi) Calculate the percentage by mass of strontium carbonate in the sample.

____ [6]

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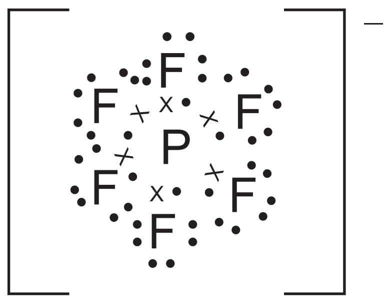
(Questions continue overleaf)

17 A typical "lithium ion battery" consists of a lithium cobalt oxide ($LiCoO_2$) electrode and a graphite electrode separated by lithium fluorophosphate ($LiPF_6$).

(a) (i) The dot and cross diagram for the fluorophosphate ion is shown below. State the octet rule and explain whether or not the atoms in the ion obey this rule.



____

____

____

____ [3]

(ii) Draw and name the shape of the PF_6^- ion.

____ [2]

(iii) Explain why PF_6^- has the shape selected.

____

____ [2]

(b) Redox reactions will occur in a working battery.

(i) Define a **redox** reaction.

____ [1]

(ii) What is the oxidation state of cobalt in $LiCoO_2$?

____ [1]

(iii) The lead–acid battery, common in many motor vehicles, relies on the following redox processes.

Balance the half-equations shown below.

$PbO_2 + SO_4^{2-} + H^+ \rightarrow PbSO_4 + H_2O$

$Pb + HSO_4^- \rightarrow PbSO_4 + H^+$

[2]

(iv) Combine the half-equations into an equation showing the overall reaction.

____ [1]

18 Electronic cigarettes have been developed as an alternative to tobacco smoking. They are controversial as some studies have suggested that they release very small amounts of metal ions, such as silver, into the air.

(a) Suggest how the vapour produced by an electronic cigarette could be tested for silver ions. Indicate the result that would be expected if silver ions were present.

____

____

____ [3]

(b) Silver ions can be used to sterilise water, 0.001 g of silver ions being required for 1000 dm^3 of water.

(i) What is the concentration of silver ions in mol dm^{-3}?

____

____ [2]

(ii) What mass of silver ions is required to sterilise an Olympic sized swimming pool which contains 2.5×10^6 dm^3 of water?

____

____ [1]

(c) Silver has also been used to dispose of chemical weapons such as mustard gas ($C_4H_8SCl_2$), which will react with silver(II) ions. The silver(II) ion is a powerful oxidising agent.

(i) Write the formula of a silver(II) ion.

____ [1]

(ii) An alternative method of disposing of mustard gas is through reaction with sodium hydroxide, which produces $C_4H_8S(OH)_2$ and sodium chloride. Write an equation for this reaction.

____ [1]

THIS IS THE END OF THE QUESTION PAPER

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For Examiner's use only	
Question Number	**Marks**
Section A	
1–10	
Section B	
11	
12	
13	
14	
15	
16	
17	
18	
Total Marks	

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Periodic Table of the Elements

For the use of candidates taking

Advanced Subsidiary and Advanced Level
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Copies must be free from notes or additions of any kind. No other type of data booklet or information sheet is authorised for use in the examinations.

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THE PERIODIC TABLE OF ELEMENTS

Group

One mole of any gas at 20 °C and a pressure of 1 atmosphere (10^5 Pa) occupies a volume of 24 dm^3.
Planck Constant = 6.63×10^{-34} J s
Gas Constant = 8.31 J mol^{-1} K^{-1}
Avogadro Constant = 6.02×10^{23} mol^{-1}

I	II											III	IV	V	VI	VII	0
1 **H** Hydrogen 1																	4 **He** Helium 2
7 **Li** Lithium 3	9 **Be** Beryllium 4											11 **B** Boron 5	12 **C** Carbon 6	14 **N** Nitrogen 7	16 **O** Oxygen 8	19 **F** Fluorine 9	20 **Ne** Neon 10
23 **Na** Sodium 11	24 **Mg** Magnesium 12											27 **Al** Aluminium 13	28 **Si** Silicon 14	31 **P** Phosphorus 15	32 **S** Sulfur 16	35.5 **Cl** Chlorine 17	40 **Ar** Argon 18
39 **K** Potassium 19	40 **Ca** Calcium 20	45 **Sc** Scandium 21	48 **Ti** Titanium 22	51 **V** Vanadium 23	52 **Cr** Chromium 24	55 **Mn** Manganese 25	56 **Fe** Iron 26	59 **Co** Cobalt 27	59 **Ni** Nickel 28	64 **Cu** Copper 29	65 **Zn** Zinc 30	70 **Ga** Gallium 31	73 **Ge** Germanium 32	75 **As** Arsenic 33	79 **Se** Selenium 34	80 **Br** Bromine 35	84 **Kr** Krypton 36
85 **Rb** Rubidium 37	88 **Sr** Strontium 38	89 **Y** Yttrium 39	91 **Zr** Zirconium 40	93 **Nb** Niobium 41	96 **Mo** Molybdenum 42	99 **Tc** Technetium 43	101 **Ru** Ruthenium 44	103 **Rh** Rhodium 45	106 **Pd** Palladium 46	108 **Ag** Silver 47	112 **Cd** Cadmium 48	115 **In** Indium 49	119 **Sn** Tin 50	122 **Sb** Antimony 51	128 **Te** Tellurium 52	127 **I** Iodine 53	131 **Xe** Xenon 54
133 **Cs** Caesium 55	137 **Ba** Barium 56	139 **La*** Lanthanum 57	178 **Hf** Hafnium 72	181 **Ta** Tantalum 73	184 **W** Tungsten 74	186 **Re** Rhenium 75	190 **Os** Osmium 76	192 **Ir** Iridium 77	195 **Pt** Platinum 78	197 **Au** Gold 79	201 **Hg** Mercury 80	204 **Tl** Thallium 81	207 **Pb** Lead 82	209 **Bi** Bismuth 83	210 **Po** Polonium 84	210 **At** Astatine 85	222 **Rn** Radon 86
223 **Fr** Francium 87	226 **Ra** Radium 88	227 **Ac**† Actinium 89															

140 **Ce** Cerium 58	141 **Pr** Praseodymium 59	144 **Nd** Neodymium 60	147 **Pm** Promethium 61	150 **Sm** Samarium 62	152 **Eu** Europium 63	157 **Gd** Gadolinium 64	159 **Tb** Terbium 65	162 **Dy** Dysprosium 66	165 **Ho** Holmium 67	167 **Er** Erbium 68	169 **Tm** Thulium 69	173 **Yb** Ytterbium 70	175 **Lu** Lutetium 71
232 **Th** Thorium 90	231 **Pa** Protactinium 91	238 **U** Uranium 92	237 **Np** Neptunium 93	242 **Pu** Plutonium 94	243 **Am** Americium 95	247 **Cm** Curium 96	245 **Bk** Berkelium 97	251 **Cf** Californium 98	254 **Es** Einsteinium 99	253 **Fm** Fermium 100	256 **Md** Mendelevium 101	254 **No** Nobelium 102	257 **Lr** Lawrencium 103

* 58–71 Lanthanum series
† 90–103 Actinium series

a x b

a = relative atomic mass (approx.)
x = atomic symbol
b = atomic number