Write your name here

Surname	Other names

Edexcel GCE

Centre Number	Candidate Number

Chemistry

Advanced Subsidiary

Unit 2: Application of Core Principles of Chemistry

Monday 7 June 2010 – Morning
Time: 1 hour 30 minutes

Paper Reference
6CH02/01

Candidates may use a calculator.

Total Marks

Instructions

- Use **black** ink or ball-point pen.
- **Fill in the boxes** at the top of this page with your name, centre number and candidate number.
- Answer **all** questions.
- Answer the questions in the spaces provided
  – *there may be more space than you need.*

Information

- The total mark for this paper is 80.
- The marks for **each** question are shown in brackets
  – *use this as a guide as to how much time to spend on each question.*
- Questions labelled with an **asterisk** (*) are ones where the quality of your written communication will be assessed
  – *you should take particular care with your spelling, punctuation and grammar, as well as the clarity of expression, on these questions.*
- A Periodic Table is printed on the back cover of this paper.

Advice

- Read each question carefully before you start to answer it.
- Keep an eye on the time.
- Try to answer every question.
- Check your answers if you have time at the end.

Turn over ▶

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7/7/7/2/

N 3 6 3 9 0 A 0 1 2 4

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SECTION A

Answer ALL the questions in this section. You should aim to spend no more than 20 minutes on this section. For each question, select one answer from A to D and put a cross in the box ☒. If you change your mind, put a line through the box ☒ and then mark your new answer with a cross ☒.

1 This question is about bond angles.

A 90°

B 104°

C 107°

D 109.5°

Select, from A to D above, the most likely value for the bond angle of

(a) HCH in methane, CH_4.

(1)

☒ **A**

☒ **B**

☒ **C**

☒ **D**

(b) FSF in sulfur hexafluoride, SF_6.

(1)

☒ **A**

☒ **B**

☒ **C**

☒ **D**

(c) FOF in oxygen difluoride, OF_2.

(1)

☒ **A**

☒ **B**

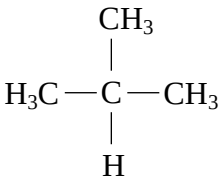
☒ **C**

☒ **D**

(Total for Question 1 = 3 marks)

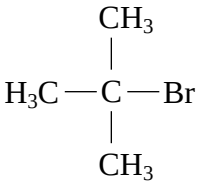
2 Consider the following compounds, **P**, **Q**, **R** and **S**.

$CH_3CH_2CH_2CH_3$



Compound P **Compound Q**

$CH_3CH_2CH_2CH_2Br$



Compound R **Compound S**

The boiling temperatures of compounds P, Q, R and S **increase** in the order

☒ **A** P Q R S

☒ **B** R S P Q

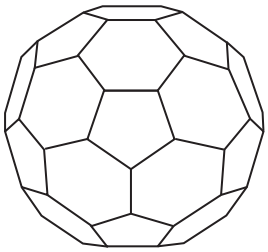
☒ **C** Q S P R

☒ **D** Q P S R

(Total for Question 2 = 1 mark)

Use this space for any rough working. Anything you write in this space will gain no credit.

3 Buckminsterfullerene has the formula C_{60}. Its structure is shown below.



The bonding in buckminsterfullerene is similar to the bonding in graphite.

Which of the following is true?

☒ **A** All the bond angles in buckminsterfullerene are 120°.

☒ **B** The melting temperature of buckminsterfullerene is higher than that of graphite.

☒ **C** There are delocalized electrons in buckminsterfullerene.

☒ **D** On complete combustion, buckminsterfullerene forms carbon dioxide and water.

(Total for Question 3 = 1 mark)

4 When concentrated sulfuric acid is added to solid sodium bromide, bromine is produced.

When concentrated sulfuric acid is added to solid sodium chloride, **no** chlorine is produced.

The reason for this difference is

☒ **A** sulfuric acid is a strong acid.

☒ **B** hydrogen chloride is a weak acid.

☒ **C** the chloride ion is a weaker reducing agent than the bromide ion.

☒ **D** bromine is less volatile than chlorine.

(Total for Question 4 = 1 mark)

Use this space for any rough working. Anything you write in this space will gain no credit.

5 Compound **X** is a white solid. On heating this compound, a colourless, acidic gas is the only gaseous product. A flame test is carried out on the solid residue and a reddish flame is observed.

Compound **X** is

- ☒ **A** calcium nitrate.
- ☒ **B** calcium carbonate.
- ☒ **C** magnesium carbonate.
- ☒ **D** strontium nitrate.

(Total for Question 5 = 1 mark)

6 Which of the following does **not** apply to the elements Mg, Ca, Sr and Ba in Group 2 of the Periodic Table?

- ☒ **A** Their oxides, MO, are all basic.
- ☒ **B** Their metal hydroxides, $M(OH)_2$, become more soluble down the group.
- ☒ **C** Their oxides, MO, react with water to form the metal hydroxide, $M(OH)_2$.
- ☒ **D** Their carbonates, MCO_3, all decompose on gentle heating.

(Total for Question 6 = 1 mark)

7 Which of the following compounds shows hydrogen bonding in the liquid state?

- ☒ **A** Hydrogen bromide, HBr
- ☒ **B** Hydrogen sulfide, H_2S
- ☒ **C** Silane, SiH_4
- ☒ **D** Ammonia, NH_3

(Total for Question 7 = 1 mark)

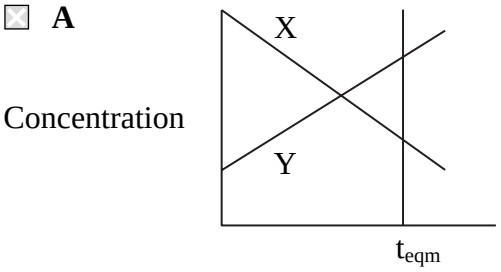
Use this space for any rough working. Anything you write in this space will gain no credit.

8 For the reversible reaction

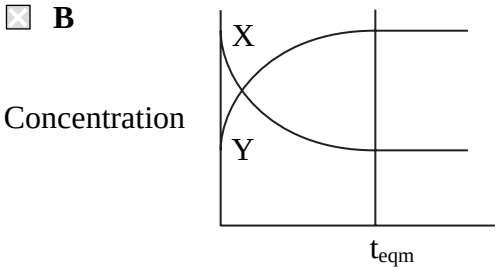
$$X \rightleftharpoons Y$$

which of the following could represent the change in the concentrations of X and Y with time, starting with a mixture of both X and Y? Equilibrium is reached at time t_{eqm}.

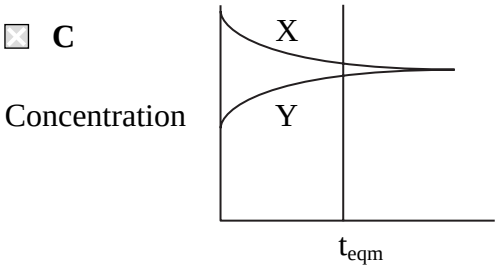
☒ **A**



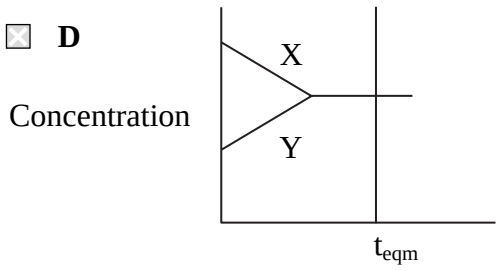
☒ **B**



☒ **C**



☒ **D**



(Total for Question 8 = 1 mark)

9 Which of the following molecules is polar?

☒ **A** Carbon dioxide, CO_2

☒ **B** Beryllium chloride, $BeCl_2$

☒ **C** Ammonia, NH_3

☒ **D** Boron trifluoride, BF_3

(Total for Question 9 = 1 mark)

Use this space for any rough working. Anything you write in this space will gain no credit.

10 The electronegativities of four pairs of elements are given below. Which pair would form the compound with the greatest ionic character?

☒ **A** 0.7 and 4.0

☒ **B** 0.7 and 3.5

☒ **C** 1.0 and 4.0

☒ **D** 0.8 and 2.8

(Total for Question 10 = 1 mark)

11 Which of the following statements about the elements in Group 7 is **incorrect**?

☒ **A** They all show variable oxidation states in their compounds.

☒ **B** They all form acidic hydrides.

☒ **C** Electronegativity decreases as the group is descended.

☒ **D** They all exist as diatomic molecules.

(Total for Question 11 = 1 mark)

12 What are the products, other than water, when chlorine is passed through cold, dilute aqueous sodium hydroxide solution?

☒ **A** NaCl and NaClO

☒ **B** NaClO and $NaClO_3$

☒ **C** NaCl and $NaClO_3$

☒ **D** NaClO and $NaClO_4$

(Total for Question 12 = 1 mark)

Use this space for any rough working. Anything you write in this space will gain no credit.

13 When solutions of iodine are titrated with aqueous sodium thiosulfate solution, $Na_2S_2O_3(aq)$, the thiosulfate ions are oxidized to

☒ **A** $S_2O_4^{2-}$

☒ **B** $S_2O_6^{2-}$

☒ **C** $S_2O_8^{2-}$

☒ **D** $S_4O_6^{2-}$

(Total for Question 13 = 1 mark)

14 The best method of converting ethanol, C_2H_5OH, into iodoethane, C_2H_5I, is to

☒ **A** heat iodine and ethanol under reflux.

☒ **B** react ethanol and potassium iodide in the presence of dilute acid.

☒ **C** heat potassium iodide and ethanol with concentrated sulfuric acid.

☒ **D** heat red phosphorus, ethanol and iodine under reflux.

(Total for Question 14 = 1 mark)

15 The use of poly(ethene) packaging has been criticised mainly because

☒ **A** the complete combustion of poly(ethene) produces dangerous fumes.

☒ **B** large amounts of oil are consumed in producing the monomer, ethene.

☒ **C** poly(ethene) degrades to form toxic products.

☒ **D** the catalyst used in the polymerization of ethene is expensive.

(Total for Question 15 = 1 mark)

16 Which of the following is essential if a species is to act as a nucleophile?

☒ **A** A lone pair of electrons.

☒ **B** A negative charge.

☒ **C** An unpaired electron.

☒ **D** A strongly polar bond.

(Total for Question 16 = 1 mark)

17 Calculate the volume of dilute sulfuric acid, concentration 0.500 mol dm^{-3}, required to neutralize 20.0 cm^3 aqueous sodium hydroxide, concentration 0.100 mol dm^{-3}.

$$H_2SO_4 + 2NaOH \rightarrow Na_2SO_4 + 2H_2O$$

☒ **A** 2.0 cm^3

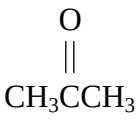
☒ **B** 4.0 cm^3

☒ **C** 8.0 cm^3

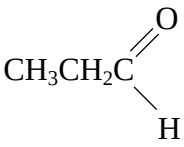
☒ **D** 20.0 cm^3

(Total for Question 17 = 1 mark)

18 Which of the following features is shown by the mass spectra of propanone and propanal?



propanone



propanal

		m/e of the molecular ion	Fragmentation pattern
☒	**A**	same	same
☒	**B**	same	different
☒	**C**	different	same
☒	**D**	different	different

(Total for Question 18 = 1 mark)

TOTAL FOR SECTION A = 20 MARKS

SECTION B

Answer ALL the questions. Write your answers in the spaces provided.

19 A student carried out an experiment to determine the concentration of ethanoic acid in a solution of vinegar.

- The student used a measuring cylinder to measure out 25.0 cm^3 of the vinegar solution.
- This solution was then transferred to a 250 cm^3 volumetric flask and the liquid level was carefully made up to the mark with distilled water.
- A pipette was used to transfer 25.0 cm^3 portions of the acidic solution to conical flasks.
- The solution was then titrated with sodium hydroxide solution, concentration 0.100 mol dm^{-3}, using phenolphthalein as the indicator.

$$CH_3COOH(aq) + NaOH(aq) \rightarrow CH_3COONa(aq) + H_2O(l)$$

Results

Titration number	1	2	3	4
Burette reading (final) / cm^3	28.55	28.00	40.35	28.05
Burette reading (initial) / cm^3	0.00	0.05	12.30	0.05
Volume of NaOH used / cm^3	28.55	27.95	28.05	28.00

(a) In this titration, what is the colour change of the phenolphthalein indicator?

(2)

From ..... **to** .....

(b) Explain why the mean titre should be based only on titrations 2, 3 and 4.

(1)

.....

.....

.....

(c) Calculate the mean titre in cm^3.

(1)

(d) (i) Using your answer to (c), calculate the number of moles of sodium hydroxide in the mean titre.

(1)

(ii) Hence state the number of moles of ethanoic acid, CH_3COOH, in 25.0 cm^3 of the **diluted** solution used in the titration.

(1)

(iii) Calculate the concentration of the **diluted** acid solution in mol dm^{-3}.

(1)

(iv) Hence calculate the concentration of the ethanoic acid in the **original** vinegar solution in mol dm^{-3}.

(1)

(v) Use your answer from (d)(iv) to state the concentration of the ethanoic acid in the **original** vinegar solution in units of g dm^{-3}.

[The molar mass of the ethanoic acid is 60 g mol^{-1}.]

(1)

(e) Suggest, with a reason, how the student's method of preparing the diluted solution could be improved.

(2)

Improvement

.....

.....

Reason

.....

.....

(f) The burette used in the titration had an uncertainty for each reading of ±0.05 cm^3.

(i) Identify, by letter, which ONE of the following should be regarded as the true value of the titre in titration number **2**?

X Between 27.90 and 28.00 cm^3

Y Between 27.925 and 27.975 cm^3

Z Between 27.85 and 28.05 cm^3

(1)

.....

(ii) Suggest ONE reason why a student may obtain volumes outside the uncertainty of the burette when performing a titration.

(1)

.....

.....

(Total for Question 19 = 13 marks)

20 (a) Propene, C_3H_6, reacts with hydrogen bromide, HBr, in an electrophilic addition reaction.

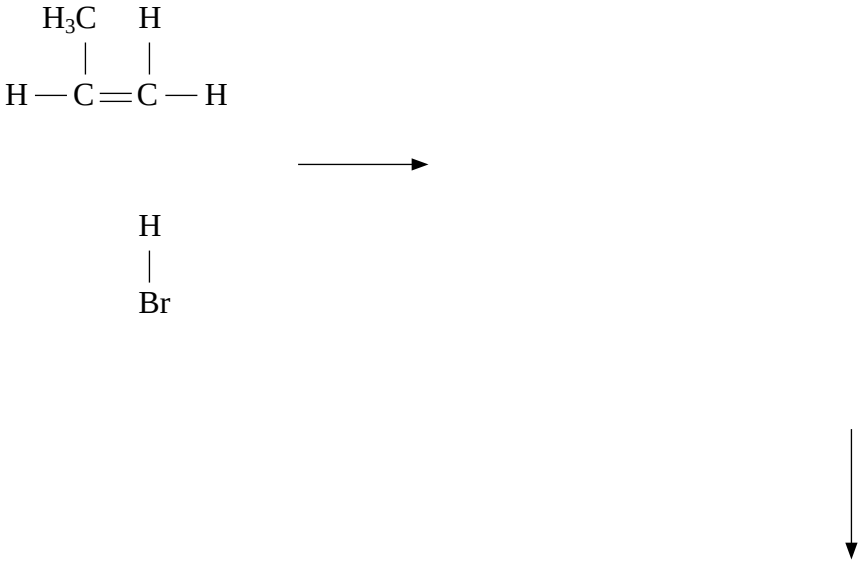
2-bromopropane is formed as the major product.

$$H_3CCH{=}CH_2 + HBr \rightarrow H_3CCH(Br)CH_3$$

(i) Complete the mechanism for the reaction, using 'curly arrows' where appropriate. Show clearly the structure of the intermediate carbocation formed.

(3)

Mechanism



(ii) Draw the structure of the alternative carbocation that can be formed in the reaction between propene and hydrogen bromide.

(1)

(b) Four isomers, each with the molecular formula $C_4H_{10}O$, are shown below.

Isomer **A**: $CH_3CH_2CH_2CH_2OH$

Isomer **B**: $CH_3CH_2CH(OH)CH_3$

Isomer **C**: $(CH_3)_3COH$

Isomer **D**: $CH_3CH(CH_3)CH_2OH$

(i) Which isomer is a secondary alcohol? Justify your answer.

(2)

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.....

.....

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(ii) Which isomer is resistant to oxidation when heated with acidified potassium dichromate(VI)? Justify your answer in terms of the structure of the isomer.

(2)

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(iii) Which isomer can be oxidized to a ketone? Draw the displayed formula of the ketone produced.

(1)

.....

(iv) Which isomers can be oxidized to an aldehyde?

(1)

.....

(v) Phosphorus(V) chloride (phosphorus pentachloride), PCl_5, is used to test for the presence of an –OH group.

What would you expect to see when any of the above four isomers, A, B, C or D, are reacted with phosphorus(V) chloride?

(1)

.....

.....

(vi) Complete the equation for the reaction shown below. State symbols are **not** required.

(2)

$C_4H_9OH + PCl_5 \rightarrow$

(Total for Question 20 = 13 marks)

21 (a) In the catalytic converter of a car engine's exhaust system, the following reaction occurs.

$2NO(g) + 2CO(g) \rightleftharpoons N_2(g) + 2CO_2(g)$ $\Delta H = -745 \text{ kJ mol}^{-1}$

The temperature in a catalytic converter is high.

(i) State the effect, if any, on the position of equilibrium if the temperature is lowered. Give a reason for your answer.

(2)

Effect .....

Reason .....

.....

(ii) The gases from the engine are **not** cooled before entering the converter. Explain why this is so.

(2)

.....

.....

.....

.....

(iii) State the effect, if any, on the position of equilibrium if the pressure on the reacting gases is increased. Give a reason for your answer.

(2)

Effect .....

Reason .....

.....

(b) Nitrogen monoxide, NO, is formed when nitrate ions, NO_3^-, in acidic solution are reduced by silver metal.

(i) Calculate the oxidation number of nitrogen in NO and in NO_3^-.

(2)

In NO .....

In NO_3^- .....

(ii) Balance the half-equation for the reduction of nitrate ions, NO_3^-, in acidic solution.

(1)

$$NO_3^- + \text{.....}H^+ + \text{.....}e^- \rightarrow NO + \text{.....}H_2O$$

(iii) Write the half-equation for the oxidation of silver metal, Ag, to silver ions, Ag^+.

(1)

(iv) Hence deduce the full ionic equation for the reaction between silver metal and nitrate ions in acidic solution. State symbols are **not** required.

(2)

(Total for Question 21 = 12 marks)

TOTAL FOR SECTION B = 38 MARKS

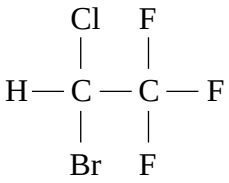
SECTION C

Answer ALL the questions. Write your answers in the spaces provided.

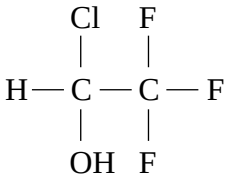
22 This question is about the chemistry of some halogenoalkanes.

Halothane is a colourless and sweet-smelling liquid. It has a boiling temperature of 50 °C. Halothane vapour was used as a general anaesthetic in hospitals during the mid to late 20th Century. Patients inhaled the halothane vapour under medical supervision. However, halothane was found to have some adverse side-effects and was therefore replaced by other halogenoalkane anaesthetics.

Halothane has the structure



In an experiment, halothane was heated in a test tube with aqueous silver nitrate and ethanol, using a water bath. Compound **X** and bromide ions were formed. The structure of compound **X** is shown below.



Compound **X**

(a) (i) Give the systematic name of halothane.

(1)

.....

(ii) Suggest the types of intermolecular force present between molecules of liquid halothane.

(2)

.....

.....

.....

.....

(iii) In the above experiment, suggest ONE reason why a water bath was used rather than heating the test tube containing the reaction mixture directly over a Bunsen flame.

(1)

.....

.....

.....

(iv) Suggest why ethanol was used in this experiment.

(1)

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.....

.....

(v) What would be seen in the test tube as the reaction progressed?

(1)

.....

.....

(vi) Write an ionic equation to show the reaction between aqueous silver ions and aqueous bromide ions. Include state symbols in your equation.

(1)

(b) Chloroethane, C_2H_5Cl, can also be used as an anaesthetic. In an experiment, chloroethane was hydrolysed by aqueous sodium hydroxide, NaOH.

(i) Name, and give the structural formula of, the organic product of the hydrolysis of chloroethane.

(2)

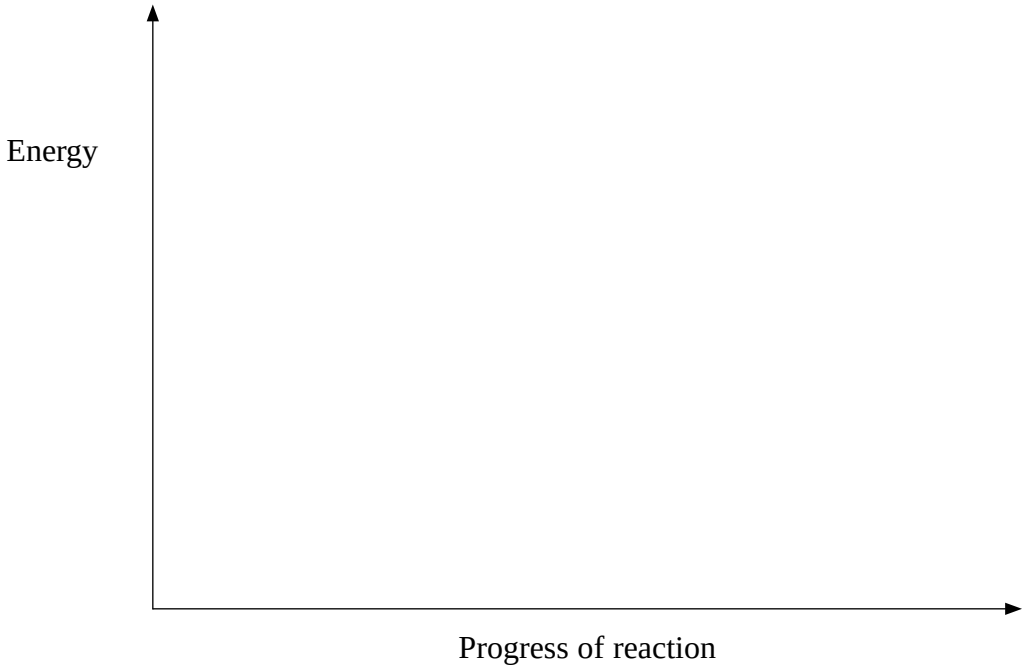
Name .....

Structural formula .....

(ii) The hydrolysis of chloroethane is an exothermic reaction which takes place in a single step.

On the diagram below, draw the energy profile for the reaction. Label clearly the activation energy for the reaction.

(3)



(c) In the early 1900s, the CFC with formula CCl_2F_2, was identified as a refrigerant which was both non-flammable and non-toxic.

(i) What does the term **CFC** stand for?

(1)

.....

(ii) Suggest ONE use for CFCs other than as a refrigerant.

(1)

.....

*(iii) In the stratosphere, CFCs are broken down by absorption of UV radiation to form chlorine free radicals.

The following two reactions occur.

$$Cl\bullet + O_3 \rightarrow ClO\bullet + O_2$$

$$ClO\bullet + O \rightarrow Cl\bullet + O_2$$

Combine these two equations to give the overall equation for the reaction of ozone in the stratosphere. State the role played by the chlorine free radical in the overall reaction. Hence explain why many scientists consider the effect of CFCs on ozone to be harmful.

(5)

(d) The compound of formula CH_2F_2 has replaced several CFCs for commercial use. If molecules of CH_2F_2 reach the stratosphere, they do not break down to produce fluorine free radicals.

(i) Suggest why C–F bonds are **not** broken in the stratosphere.

(1)

.....

.....

.....

*(ii) The compound CH_2F_2 acts as a greenhouse gas when it absorbs a particular type of radiation.

Name the type of radiation and explain why a molecule of CH_2F_2 is able to absorb this radiation.

(2)

.....

.....

.....

.....

(Total for Question 22 = 22 marks)

TOTAL FOR SECTION C = 22 MARKS
TOTAL FOR PAPER = 80 MARKS

The Periodic Table of Elements

1	2											3	4	5	6	7	0 (8) (18)
							1.0 H hydrogen 1										4.0 He helium 2
(1)	(2)											(13)	(14)	(15)	(16)	(17)	
6.9 Li lithium 3	9.0 Be beryllium 4											10.8 B boron 5	12.0 C carbon 6	14.0 N nitrogen 7	16.0 O oxygen 8	19.0 F fluorine 9	20.2 Ne neon 10
23.0 Na sodium 11	24.3 Mg magnesium 12	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	27.0 Al aluminium 13	28.1 Si silicon 14	31.0 P phosphorus 15	32.1 S sulfur 16	35.5 Cl chlorine 17	39.9 Ar argon 18
39.1 K potassium 19	40.1 Ca calcium 20	45.0 Sc scandium 21	47.9 Ti titanium 22	50.9 V vanadium 23	52.0 Cr chromium 24	54.9 Mn manganese 25	55.8 Fe iron 26	58.9 Co cobalt 27	58.7 Ni nickel 28	63.5 Cu copper 29	65.4 Zn zinc 30	69.7 Ga gallium 31	72.6 Ge germanium 32	74.9 As arsenic 33	79.0 Se selenium 34	79.9 Br bromine 35	83.8 Kr krypton 36
85.5 Rb rubidium 37	87.6 Sr strontium 38	88.9 Y yttrium 39	91.2 Zr zirconium 40	92.9 Nb niobium 41	95.9 Mo molybdenum 42	[98] Tc technetium 43	101.1 Ru ruthenium 44	102.9 Rh rhodium 45	106.4 Pd palladium 46	107.9 Ag silver 47	112.4 Cd cadmium 48	114.8 In indium 49	118.7 Sn tin 50	121.8 Sb antimony 51	127.6 Te tellurium 52	126.9 I iodine 53	131.3 Xe xenon 54
132.9 Cs caesium 55	137.3 Ba barium 56	138.9 La* lanthanum 57	178.5 Hf hafnium 72	180.9 Ta tantalum 73	183.8 W tungsten 74	186.2 Re rhenium 75	190.2 Os osmium 76	192.2 Ir iridium 77	195.1 Pt platinum 78	197.0 Au gold 79	200.6 Hg mercury 80	204.4 Tl thallium 81	207.2 Pb lead 82	209.0 Bi bismuth 83	[209] Po polonium 84	[210] At astatine 85	[222] Rn radon 86
[223] Fr francium 87	[226] Ra radium 88	[227] Ac* actinium 89	[261] Rf rutherfordium 104	[262] Db dubnium 105	[266] Sg seaborgium 106	[264] Bh bohrium 107	[277] Hs hassium 108	[268] Mt meitnerium 109	[271] Ds darmstadtium 110	[272] Rg roentgenium 111							

Key

relative atomic mass
atomic symbol
name
atomic (proton) number

Elements with atomic numbers 112-116 have been reported but not fully authenticated

* Lanthanide series

* Actinide series

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	163 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