YISHUN SECONDARY SCHOOL
PRELIMINARY EXAMINATION 2024
SECONDARY 4 EXPRESS

CANDIDATE NAME							
CLASS					INDEX NUMBER		

CHEMISTRY **6092/02**
Paper 2 **23 August 2024**
1 hour 45 minutes

Candidates answer on the Question Paper.
No Additional Materials are required.

READ THESE INSTRUCTIONS FIRST

Write your name, class and index number on the work you hand in.
Write in dark blue or black pen.
You may use an HB pencil for any diagrams or graphs.
Do not use staples, paper clips, glue or correction fluid.

Section A
Answer **all** questions in the spaces provided.

Section B
Answer **one** question.
Write your answers in the spaces provided.

Electronic calculators may be used.

The number of marks is given in brackets [ ] at the end of each question or part question.
A copy of the Periodic Table is printed on page **24**.

The use of an approved scientific calculator is expected, where appropriate.

Section A

Answer **all** questions.

1 Use the list of substances to answer the following questions.

calcium chloride

zinc

helium

sodium chloride

graphite

copper

sodium

copper(II) carbonate

You may use each substance once, more than once or not at all.

(a) Which substance has a giant covalent structure?

.....[1]

(b) Which substance only conducts electricity in molten state?

.....[1]

(c) Which substance can be decomposed by heat to give a gaseous product at room temperature and pressure?

.....[1]

(d) Which **two** substances form the alloy brass?

.....[1]

(e) Which substance is a noble gas?

.....[1]

(f) Which substance can be oxidised by oxygen to form an amphoteric oxide?

.....[1]

[total: 6]

2 Fig. 2.1 shows two different experimental set up for electroplating an object with silver.

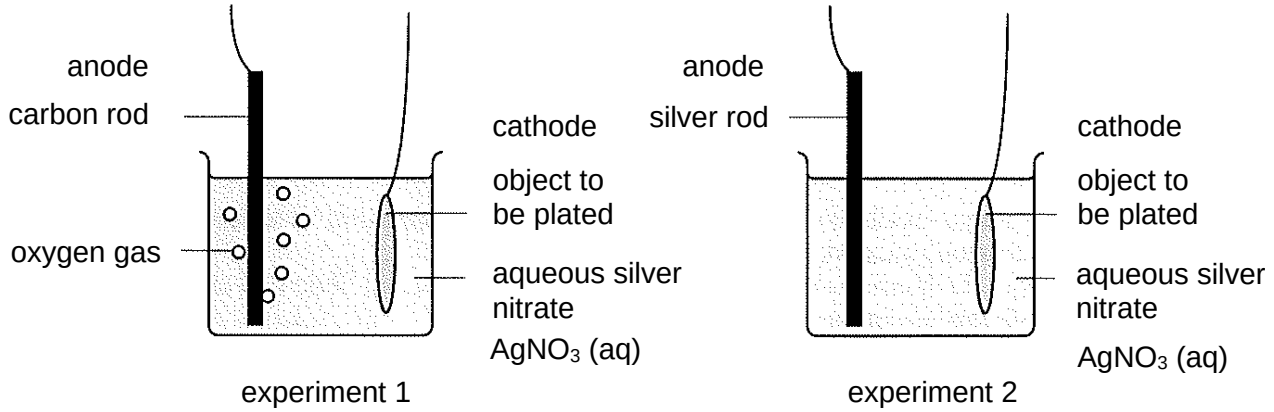

Fig. 2.1

(a) Write equations, with state symbols, to show the reactions that happen at the anode and cathode during each experiment.

experiment 1

anode: .....

cathode: .....

experiment 2

anode: .....

cathode: .....[3]

(b) At the beginning of each experiment, the student removes a sample of the electrolyte, aqueous silver nitrate, and puts it into separate test tubes. The student then adds a few drop of aqueous sodium chloride to each test tube.

Describe and explain what the student would see.

.....

.....[1]

(c) After some time, the student observes that no more silver is being deposited on the object in experiment 1 but more silver is being deposited on the object in experiment 2.

Suggest a reason for this observation in both experiments 1 and 2.

.....

.....

.....[2]

(d) In Fig. 2.2, an iron object is placed in a beaker of aqueous silver nitrate, a silver coating forms on the iron. If a gold object is placed in aqueous silver nitrate, no reaction happens.

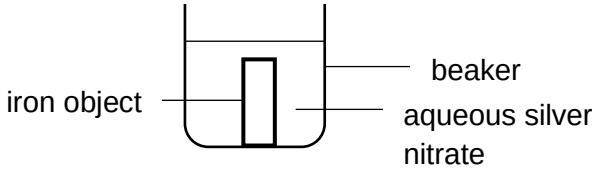

Fig. 2.2

Explain why.

.....

.....

.....[2]

[total: 8]

3 **(a)** Minerals contain salts which are mainly ionic compounds.

Examples include potassium sulfate, which is used as a fertiliser and lead(II) nitrate, which is used in coating photothermographic paper.

(i) In Table 3.1, state the reagents which may be used to prepare the salts, potassium sulfate and lead(II) nitrate.

Table 3.1

salt	reagent 1	reagent 2
potassium sulfate		
lead(II) nitrate		

[2]

(ii) Aqueous solutions of potassium sulfate and excess lead(II) nitrate were mixed to produce an insoluble salt.

With the aid of a balanced chemical equation, calculate the mass of insoluble salt that can be obtained from the reaction when 15 cm^3 of 2.0 mol/dm^3 potassium sulfate solution is used.

mass of salt = …… g [3]

(b) More than 90 % of the Earth's crust is composed of silicate minerals which contain metal ions ionically bonded to silicate ions.

Examples of naturally occurring silicates are shown in Table 3.2.

Table 3.2

name of silicate compound	formula
willemite	Zn_2SiO_4
castorite	$LiAlSi_4O_{10}$
chrysotile	$Mg_3Si_2O_5(OH)_4$

(i) The formulae of silicate compounds are not simple. Some silicate compounds contain one type of metal, others contain more than one. All silicate ions contain silicon and oxygen. Both the numbers of the atoms and the charges on the ions vary.

Give the formulae and charges of the silicate ions present in Table 3.2.

willemite ..... castorite ..... chrysotile ..... [2]

(ii) Albite is a silicon mineral that has the following percentage composition by mass.

element	percentage by mass
sodium	8.7 %
aluminium	10.3 %
silicon	32.3 %
oxygen	48.7 %

Use the data to work out the empirical formula of albite.

[2]

[total: 9]

4 Flerovium, F*l* (atomic number:114) was first made in research laboratories in 1999.

(a) Flerovium was made by bombarding atoms of plutonium, Pu (atomic number: 94), with atoms of element **Z**.

The nucleus of one atom of plutonium combined with the nucleus of one atom of element **Z**.

This formed the nucleus of one atom of Flerovium.

Suggest the identity of element **Z**.

.....[1]

(b) With the use of the Periodic Table, complete Table 4.1 to fill in the missing information about an atom of flerovium.

Table 4.1

number of electron shells	number of valence electrons

[1]

(c) Two isotopes of Flerovium are ^{288}F*l* and ^{289}F*l*.

State a similarity and difference between the two nuclei of the two isotopes.

.....

.....

.....[2]

(d) Only a relatively small number of atoms of flerovium has been made in the laboratory and the properties of flerovium have not yet been investigated.

It has been suggested that flerovium behaves like a typical metal.

(i) Draw a labelled diagram to show the type of bonding in flerovium.

[2]

(ii) State a physical property of flerovium.

.....[1]

(iii) Suggest a chemical property of flerovium oxide.

.....[1]

[total: 8]

5 Chlorophyll, xanthophyll and phaeophytin are green pigments that may be found in leaves. Aged chlorophyll can decompose into phaeophytin, a grey pigment molecule.

A student carried out a chromatographic experiment to compare the extracts of spinach leaves obtained from 2 different sources, and he obtained the following chromatogram.

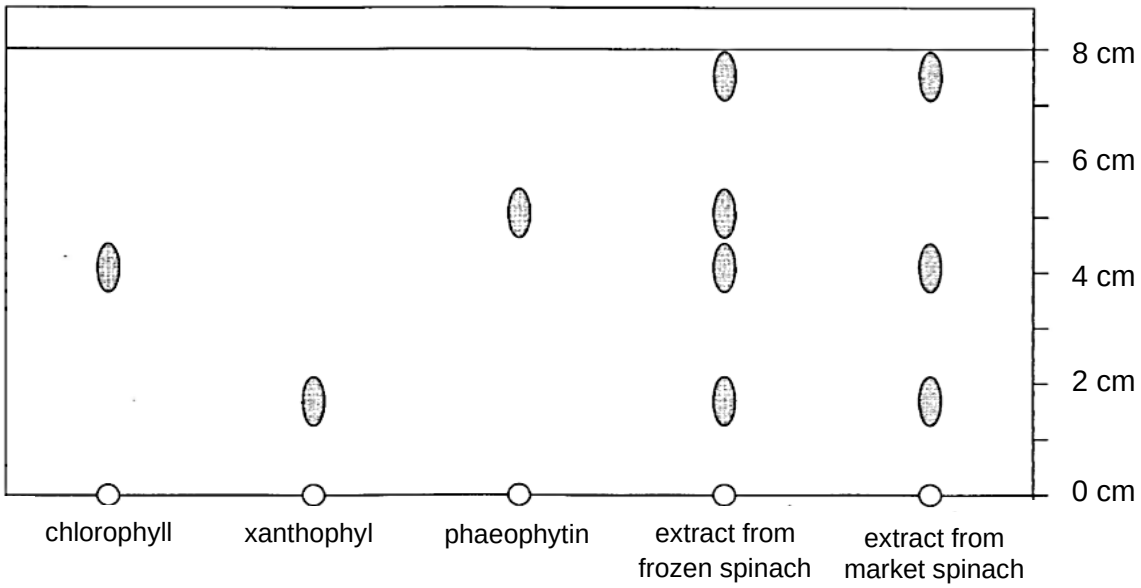

Fig. 5.1

(a) Calculate the R_f value of phaeophytin in the experiment.

[1]

(b) Describe the results obtained for the extract from frozen spinach.

.....

.....[1]

(c) The student concluded that spinach bought from the market is fresher than frozen spinach.

Explain his reasoning.

.....

.....

.....[2]

[total: 4]

[Turn over

6 Fertilisers are used to promote plant growth.

Two commonly used chemicals found in fertilisers are ammonium phosphate, $(NH_4)_3PO_4$, and calcium dihydrogenphosphate, $Ca(H_2PO_4)_2$.

(a) Describe tests to distinguish between these two chemicals.

.....

.....

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.....

.....

.....[3]

(b) Many fertilisers are manufactured from ammonia.

Fig. 6.1 shows information about the percentage yield of ammonia present at different temperatures and pressures.

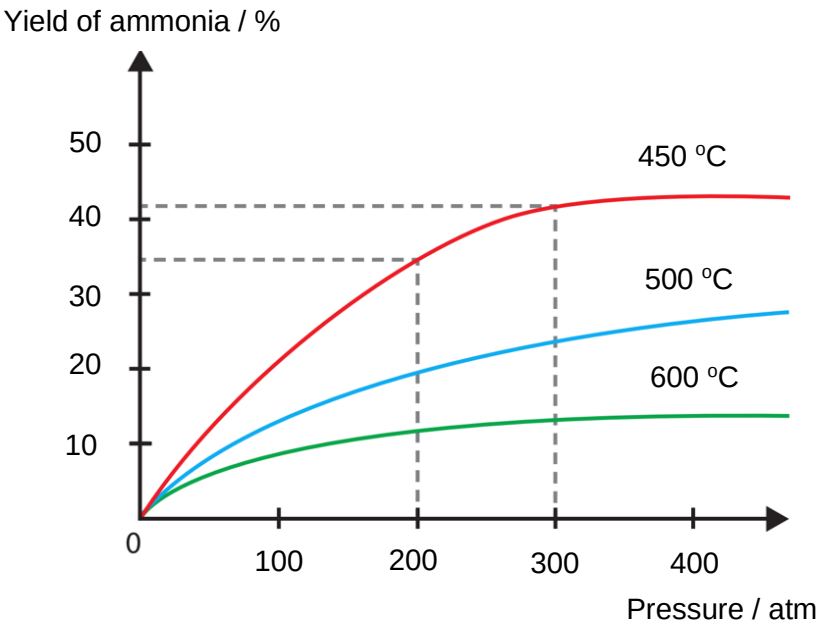


Fig. 6.1

(i) Use Fig. 6.1 to deduce the effect of decreasing temperature on the percentage yield of ammonia.

.....

.....[1]

(ii) Suggest one advantage and one disadvantage of using a pressure of 300 atm instead of 200 atm.

.....

.....

.....[2]

(c) The extensive use of fertilisers and possibly the effect of acid rain tend to increase the acidity of the soil.

State why it is necessary to control soil acidity and explain how this can be done.

.....

.....

.....[2]

[total: 8]

7 **(a)** A student conducted two experiments to investigate the relative reactivity of **iron** and two other solid metals **X** and **Y**.

In experiment 1, he heated each of the metal oxides in a test tube and observed if there was any change.

In experiment 2, he tested metals **X** and **Y** with aqueous iron(II) sulfate.

All sulfate solutions of **X** and **Y** are colourless.

He then tabulated the results of both experiments in Table 7.1 and 7.2.

Table 7.1

experiment 1	oxide of iron	oxide of **X**	oxide of **Y**
action of heat	no change	no change	metal **Y** is formed

Table 7.2

experiment 2	metal **X**	metal **Y**
addition of metal into aqueous iron(II) sulfate	a reaction occurs	solution remains green

(i) Deduce the order of reactivity of iron, **X** and **Y**, in terms of increasing reactivity.

.....[1]

(ii) When metal **X** is added into aqueous iron(II) sulfate, a reaction occurs.

Describe and explain **all** observations when **X** is placed in aqueous iron(II) sulfate in experiment 2.

.....

.....

.....[3]

(b) Fig. 7.1 shows a wire fence which is held up by steel posts. The fence was recently blown down by strong winds. It was found that the steel posts had rusted badly at ground level.

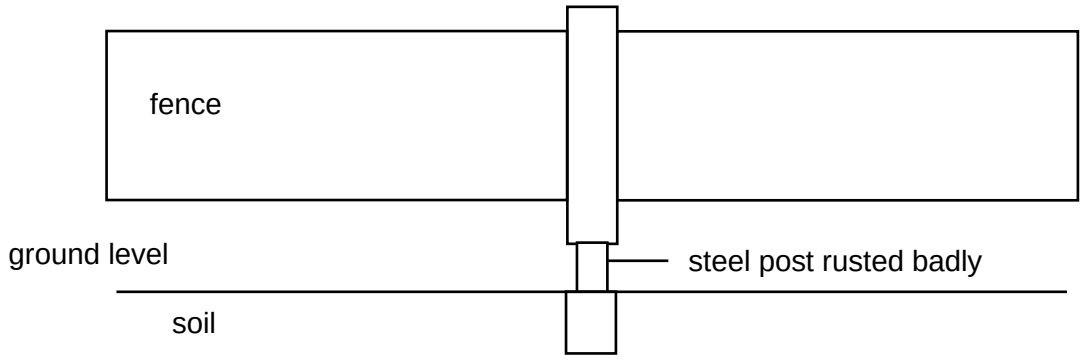


Fig. 7.1

(i) Suggest one reason why the steel posts had rusted badly at the ground level as shown in Fig. 7.1.

.....[1]

(ii) One way to protect the steel post is by galvanising.
Explain why galvanising is preferred to painting.

.....

.....

.....

.....[2]

[total: 7]

8 Poly(propene) and nylon are used to make strong, waterproof ropes.

Poly(propene) is an addition polymer. Nylon is a condensation polymer.

(a) Describe the differences between addition polymers and condensation polymers.

.....

.....

.....

.....[2]

(b) There are several types of nylon. One type of nylon is nylon-6,6.

Fig. 8.1 shows the repeating unit of nylon-6,6.

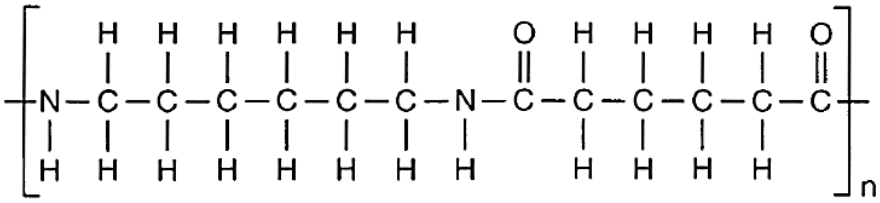


Fig. 8.1

(i) Draw the structures of the two monomers that react to form nylon-6,6.

monomer 1

monomer 2

[2]

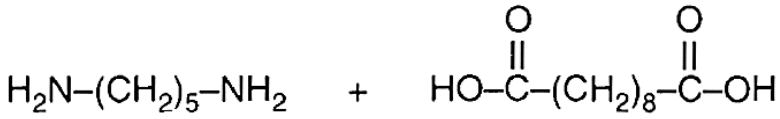
(ii) During the manufacturing process, the chain length of the nylon is controlled so that the nylon polymer molecules have an average relative molecular mass in the range 12 000 to 20 000.

What is the range of the average number of repeating units in the nylon-6,6 molecules?

Show your working.

[2]

(c) Nylon-5,10 is made by reacting these two monomers together.



(i) Draw the repeating unit of nylon-5,10.

[1]

(ii) Give one similarity between the structures of the repeating units of nylon-6,6 and nylon-5,10.

.....

.....

.....[1]

[total: 8]

9 Group 2 metals are known as the alkaline earth metals. Below are some information about them.

Discovery

The alkaline earth metals are so reactive that they are never found in elemental form in nature. Compounds of calcium and beryllium have been known and used since prehistoric times while most of the other compounds of the alkaline earth metals were discovered starting in the early 15th century.

Magnesium, calcium, strontium and barium were first produced by Humphry Davy in 1808, whereas beryllium was independently isolated by Friedrich Wöhler and Antoine Bussy in 1828 by reducing beryllium chloride with potassium in a platinum crucible.

Atomic and Ionic Radii

The radii of Group 2 metal atoms and ions can be measured.
Table 9.1 shows some information about atomic radii and ionic radii of some Group 2 metals.

Table 9.1

element	number of shells of electrons in atom	atomic radius / pm	number of shells of electrons in 2+ ion	ionic radius / pm
beryllium	2	89		31
magnesium	3	136		65
calcium	4	174		99

Chemical reaction with cold water

Group 2 metals display similar chemical reactions as alkali metals when added to cold water.
Table 9.2 shows the observations when Group 2 metals are added to cold water.

Table 9.2

Group 2 metals	observations with cold water
beryllium	no reaction
magnesium	very slow reaction
calcium	moderate reaction
strontium	very fast reaction

Nature and solubility of the hydroxides

The hydroxides of magnesium, calcium and barium are basic hydroxides and the basic strength increases down the group.

The solubilities of the metal hydroxides are shown in Table 9.3.

Table 9.3

substance	solubility
beryllium hydroxide	soluble in solutions containing an excess of OH^- ions.
magnesium hydroxide	insoluble in water
calcium hydroxide	slightly soluble in water
barium hydroxide	soluble in water

(a) Complete Table 9.1 to show the number of shells of electrons in 2+ ions. [1]

(b) Describe the trend in atomic radii for Group 2 and use the data to explain this trend.

.....

.....

.....[2]

(c) Describe the change in the radius when a beryllium atom forms a beryllium ion.

.....

.....[1]

(d) Barium lies below strontium in Group 2.
State, giving a reason, how you would expect barium to react with cold water.

.....

.....

.....[2]

(e) Using the information provided in Table 9.3, state the nature of beryllium hydroxide.
Explain your reasoning.

.....

.....

.....[2]

(f) A student prepared an aqueous solution of calcium chloride by reacting calcium with dilute hydrochloric acid. The student added the exact amount of calcium required to react with the dilute hydrochloric acid used. After carrying out the experiment, the student accidentally added more calcium. The student was surprised that the extra calcium still reacted.
Explain the observations written above.

Your answer should:

- describe the observation of the experiment after adding more calcium
- use evidence from the information to explain the observation
- include a balanced chemical equation with state symbols in the explanation

.....

.....

.....

.....

.....

.....

.....[4]

[total: 12]

Section B

Answer **one** question from this section.

10 **(a)** Hydrocarbons obtained from crude oil are feedstocks for many industrial processes.
New substances are often made by extending the carbon chain of these hydrocarbons.
One example of this is the production of a nitrile from halogen alkane.
Propanenitrile can be formed from the reaction of bromoethane with hydrogen cyanide.

bromoethane | hydrogen cyanide | propanenitrile | hydrogen bromide

Fig. 10.1

(i) Table 10.1 shows the bond energies of the covalent bonds present in the substances involved in the reaction.

Table 10.1

bond	bond energy in kJ/mol
C – C	347
C – H	413
C – Br	276
C ≡ N	891
H – Br	363

Use the data in Table 10.1 to calculate the enthalpy change when one mole of propanenitrile is produced in the reaction above.

[2]

(ii) Draw the energy profile diagram for this reaction. Label clearly the activation energy, E_a and enthalpy change, ΔH on your diagram.

[3]

(iii) HBr is soluble in water and forms hydrobromic acid. Explain why HBr becomes acidic in water.

.....

.....[1]

(b) Hydrocarbons are categorised into groups called the homologous series. The structures in Fig. 10.2 are of the first two members of a homologous series known as the cyclopropanes.

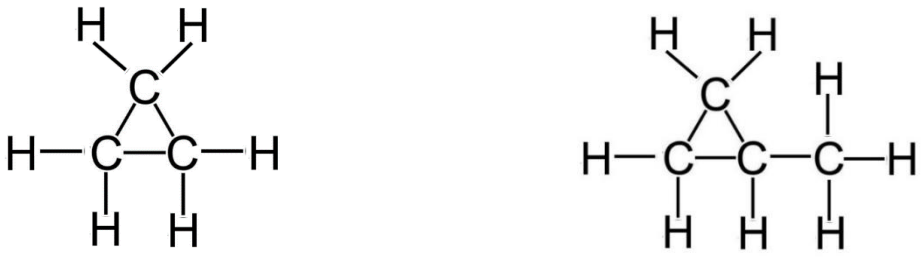


Fig. 10.2

Members of the same homologous series have a general formula.

(i) Other than having the same general formula, state one other characteristic of a homologous series by referring to the two structural formulae in Fig. 10.2.

.....

.....[1]

(ii) Deduce the general formula for the cyclopropane homologous series.

.....[1]

(iii) Compounds in this homologous series react with chlorine.
Name this type of reaction.
Give a reason why it is also known as a photochemical reaction.

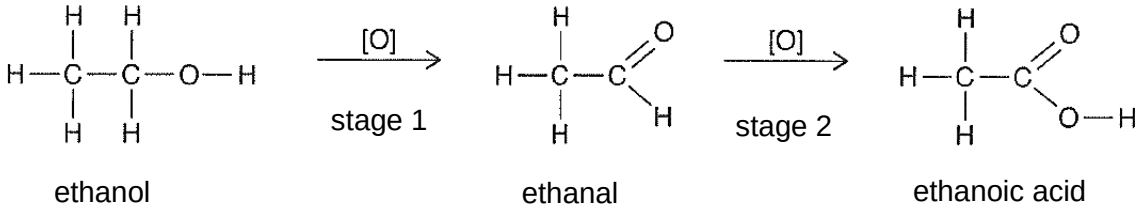
.....

.....

.....[2]

[total: 10]

11 The oxidation of ethanol to ethanoic acid happens in two stages.
Fig.11.1 shows the organic product that forms at the end of each stage.
The [O] represents an oxygen atom from an oxidising agent.



ethanol ethanal ethanoic acid

Fig. 11.1

(a) Name the substance that can oxidise ethanol to ethanoic acid in the laboratory.

.....[1]

(b) **(i)** Ethanol and ethanoic acid are each the second member of a different homologous series.

Complete table 11.1 to show the name and formula of the **third member** of each series.

Table 11.1

name of series	alcohols	carboxylic acid
name of third member		
structural formula of third member		

[2]

(ii) Ethanal is the second member of the aldehydes homologous series.

Deduce the structural formula of the **first member** of this series.

[1]

(c) Ethanol can be manufactured from either ethene or glucose.

(i) Write an equation for the production of ethanol from ethene and state the conditions under which the reaction takes place.

.....

.....

.....[2]

(ii) The fermentation of glucose can be represented by the following equation.

$$C_6H_{12}O_6 \rightarrow 2C_2H_5OH + 2CO_2$$

Calculate the maximum mass of ethanol that could be made from 36 tonnes of glucose.

1 tonne = 1×10^6 g

[2]

(iii) Explain why ethanol made from ethene is a non-renewable fuel but that made from glucose is a renewable fuel.

.....

.....

.....

.....[2]

[total: 10]

The Periodic Table of Elements

Group																	
1	2											13	14	15	16	17	18
							1 H hydrogen 1										2 He helium 4
3 Li lithium 7	4 Be beryllium 9		Key proton (atomic) number atomic symbol name relative atomic mass									5 B boron 11	6 C carbon 12	7 N nitrogen 14	8 O oxygen 16	9 F fluorine 19	10 Ne neon 20
11 Na sodium 23	12 Mg magnesium 24	3	4	5	6	7	8	9	10	11	12	13 Al aluminium 27	14 Si silicon 28	15 P phosphorus 31	16 S sulfur 32	17 Cl chlorine 35.5	18 Ar argon 40
19 K potassium 39	20 Ca calcium 40	21 Sc scandium 45	22 Ti titanium 48	23 V vanadium 51	24 Cr chromium 52	25 Mn manganese 55	26 Fe iron 56	27 Co cobalt 59	28 Ni nickel 59	29 Cu copper 64	30 Zn zinc 65	31 Ga gallium 70	32 Ge germanium 73	33 As arsenic 75	34 Se selenium 79	35 Br bromine 80	36 Kr krypton 84
37 Rb rubidium 85	38 Sr strontium 88	39 Y yttrium 89	40 Zr zirconium 91	41 Nb niobium 93	42 Mo molybdenum 96	43 Tc technetium –	44 Ru ruthenium 101	45 Rh rhodium 103	46 Pd palladium 106	47 Ag silver 108	48 Cd cadmium 112	49 In indium 115	50 Sn tin 119	51 Sb antimony 122	52 Te tellurium 128	53 I iodine 127	54 Xe xenon 131
55 Cs caesium 133	56 Ba barium 137	57–71 lanthanoids	72 Hf hafnium 178	73 Ta tantalum 181	74 W tungsten 184	75 Re rhenium 186	76 Os osmium 190	77 Ir iridium 192	78 Pt platinum 195	79 Au gold 197	80 Hg mercury 201	81 Tl thallium 204	82 Pb lead 207	83 Bi bismuth 209	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 lanthanum 139	58 Ce cerium 140	59 Pr praseodymium 141	60 Nd neodymium 144	61 Pm promethium –	62 Sm samarium 150	63 Eu europium 152	64 Gd gadolinium 157	65 Tb terbium 159	66 Dy dysprosium 163	67 Ho holmium 165	68 Er erbium 167	69 Tm thulium 169	70 Yb ytterbium 173	71 Lu lutetium 175
actinoids	89 Ac actinium –	90 Th thorium 232	91 Pa protactinium 231	92 U uranium 238	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 –

The volume of one mole of any gas is 24 dm^3 at room temperature and pressure (r.t.p.).
The Avogadro constant, $L = 6.02 \times 10^{23}\ mol^{-1}$.