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CO-ORDINATED SCIENCES

0654/42

Paper 4 Theory (Extended)

May/June 2024

2 hours

You must answer on the question paper.

No additional materials are needed.

INSTRUCTIONS

- Answer **all** questions.
- Use a black or dark blue pen. You may use an HB pencil for any diagrams or graphs.
- Write your name, centre number and candidate number in the boxes at the top of the page.
- Write your answer to each question in the space provided.
- Do **not** use an erasable pen or correction fluid.
- Do **not** write on any bar codes.
- You may use a calculator.
- You should show all your working and use appropriate units.

INFORMATION

- The total mark for this paper is 120.
- The number of marks for each question or part question is shown in brackets [].
- The Periodic Table is printed in the question paper.

This document has **28** pages. Any blank pages are indicated.



1 (a) Fig. 1.1 is a diagram of a wind-pollinated flower.

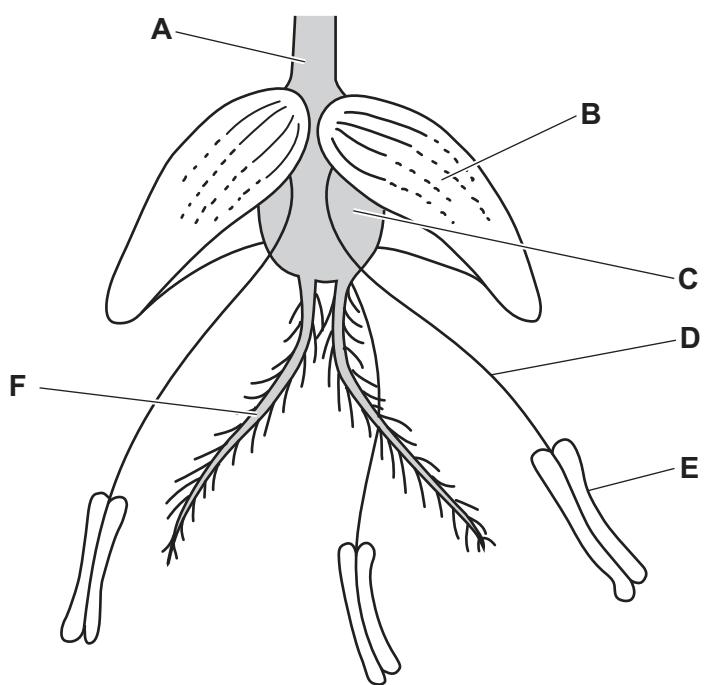


Fig. 1.1

(i) State which letter in Fig. 1.1 identifies the part where:

fertilisation occurs [1]

pollen is produced. [1]

[2]

(ii) Describe **two visible** pieces of evidence in Fig. 1.1 that show the flower is adapted for wind-pollination.

1 [1]

..... [1]

2 [1]

..... [1]

[2]





(b) Fig. 1.2 is a photomicrograph of pollen from an **insect**-pollinated flower.

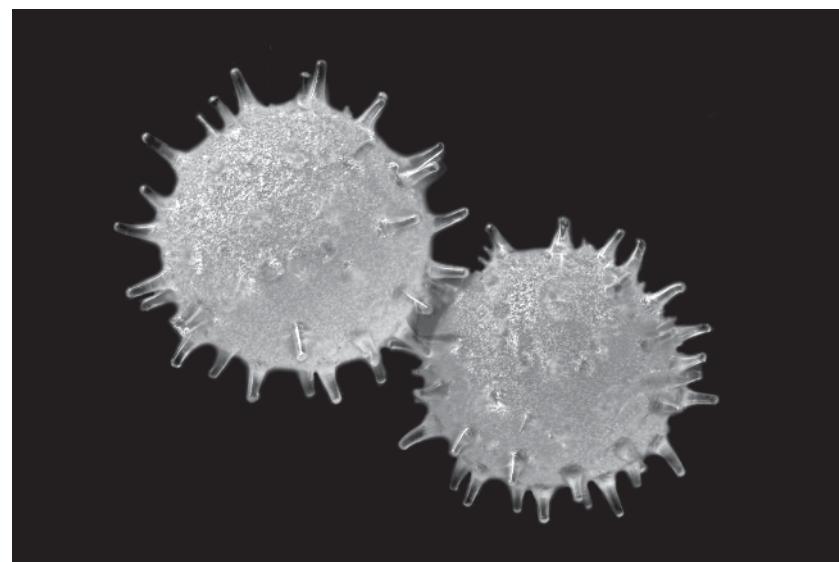


Fig. 1.2

Describe **two** ways the appearance of pollen from a wind-pollinated flower is different from the pollen from an insect-pollinated flower.

1

.....

2

.....

[2]

(c) Some plants can reproduce asexually and sexually.

(i) State **two** advantages of sexual reproduction compared to asexual reproduction in plants.

1

.....

2

.....

[2]

(ii) Suggest a situation where asexual reproduction is more useful to a plant in the wild than sexual reproduction.

.....

.....

.....

[1]





(d) Reproduction is one of the characteristics of living organisms.

State **two** other characteristics of living organisms.

1

2

[2]

[Total: 11]

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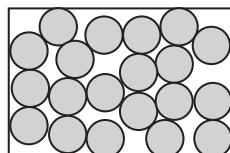
2 A student heats three substances **X**, **Y** and **Z** in a water-bath.

Table 2.1 shows the state of the three substances before heating, during heating and after cooling.

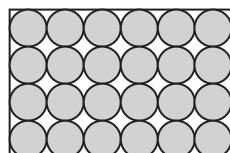
Table 2.1

substance	before heating	during heating	after cooling
X	solid	liquid	solid
Y	liquid	liquid	liquid
Z	solid	solid	solid

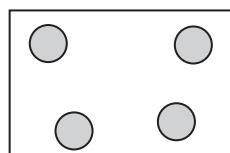
(a) Draw **one** line from substance **X** and **one** line from substance **Y** to show the arrangement of the particles before heating.



substance **X**



substance **Y**



[2]

(b) Describe the difference in the **movement** of the particles in a solid and in a liquid.

solid

.....

liquid

.....

[2]





(c) Explain how we know that the change to substance **X** is a physical change and **not** a chemical change.

.....

 [2]

(d) Substance **Z** is the ionic compound sodium chloride, NaCl .

Draw a dot-and-cross diagram to show the ionic bonding in sodium chloride.

.....

 [2]

(e) Fig. 2.1 shows the electrolysis of concentrated aqueous sodium chloride.

Complete the **three** labels on Fig. 2.1 to show the products made.

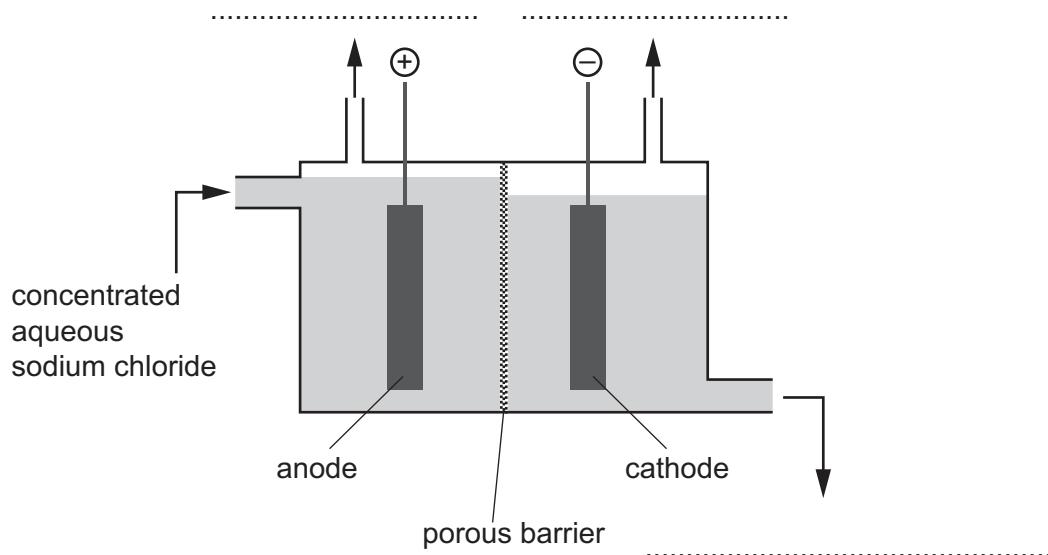


Fig. 2.1

[3]

[Total: 11]





3 Fig. 3.1 shows a sea turtle.

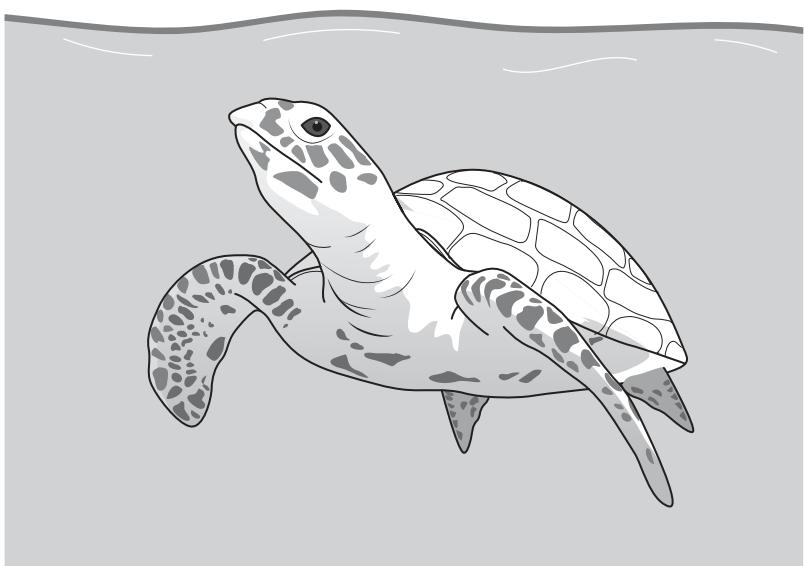


Fig. 3.1

(a) (i) On Fig. 3.1, draw an arrow to show the direction of the weight force acting on the sea turtle.

Label your arrow with the letter **W**.

[1]

(ii) Complete the sentence to describe weight.

Weight is a force caused by the effect of a field
on a

[1]

(b) The sea turtle travels a distance of 1200 km in 20 days.

Calculate the average speed of the sea turtle.

Give your answer in km/h.

average speed = km/h [3]





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(c) A team of scientists fits a tracker unit to the sea turtle to monitor its location.

The tracker unit sends a signal using radio waves each time the sea turtle moves to the surface of the water.

(i) Radio waves are part of the electromagnetic spectrum.

Complete the sentences to compare radio waves to visible light.

Radio waves have a frequency and

a wavelength than visible light.

Radio waves and visible light both travel at m/s in a vacuum.

[2]

(ii) The radio waves emitted by the tracker unit have a frequency of 1.5×10^9 Hz.

Calculate the wavelength of the radio waves.

$$\text{wavelength} = \dots \text{m} \quad [2]$$

(iii) The tracker unit uses a battery with an electromotive force (e.m.f.) of 11 V that provides a power output of 22 mW.

The battery can transfer a total charge of 24 000 C before it needs replacing.

Calculate the time for which the battery operates before it needs replacing.

$$\text{time} = \dots \text{s} \quad [4]$$

[Total: 13]





4 (a) Blood glucose concentration is controlled so that it remains within set limits.

State the name given to this type of control.

..... [1]

(b) Fig. 4.1 shows the blood glucose concentration of a person after they have eaten a meal.

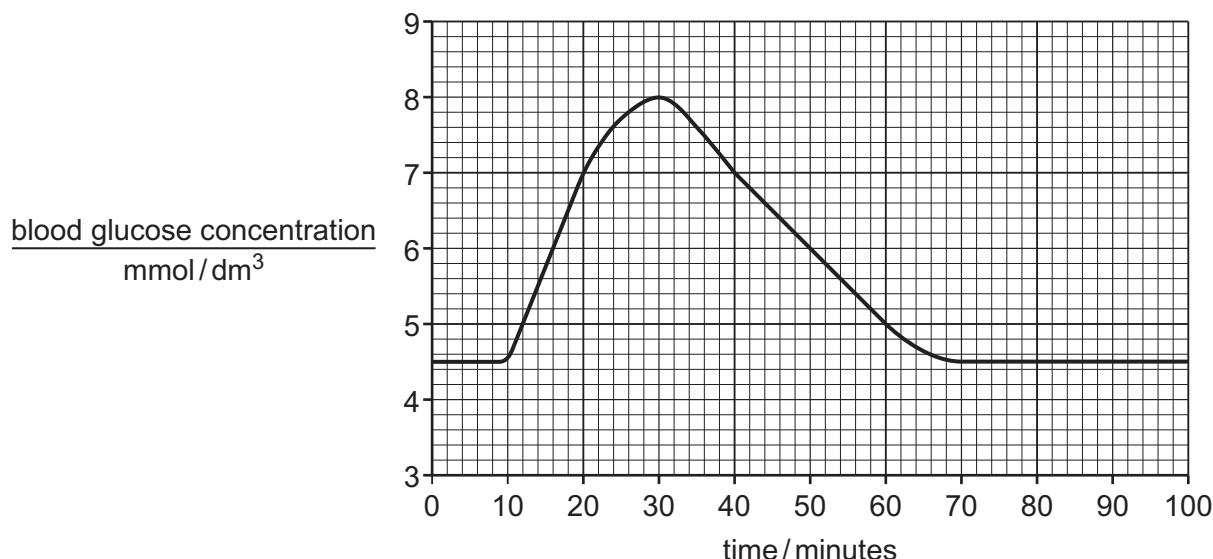


Fig. 4.1

Complete the sentences to describe and explain the changes seen in Fig. 4.1.

Carbohydrates such as starch are broken down by the enzyme

..... to form simpler sugars.

These simpler sugars are absorbed into the blood. After 30 minutes, the blood glucose concentration reaches a maximum of mmol/dm³.

The increase in blood glucose concentration is detected and the hormone insulin is released from the

Insulin causes glucose to be converted to

This is then stored in the reducing the blood glucose concentration to its previous level.

[5]





(c) State the names of **two** hormones that increase blood glucose concentration.

1

2

[2]

(d) State the name of the component of blood that transports hormones.

..... [1]

(e) Table 4.1 compares nervous and hormonal control.

Complete Table 4.1.

Table 4.1

	nervous control	hormonal control
form of transmission		chemical hormones
relative speed of action		
relative longevity of action		

[3]

[Total: 12]





5 Some students investigate the reaction between marble chips and dilute hydrochloric acid.

They react marble chips of three different sizes, **A**, **B** and **C**, with excess dilute hydrochloric acid.

They use the same mass of marble chips, the same concentration of acid and the same temperature for each experiment.

The students measure the volume of carbon dioxide gas every 30 seconds until the reaction finishes.

Fig. 5.1 shows a graph of their results.

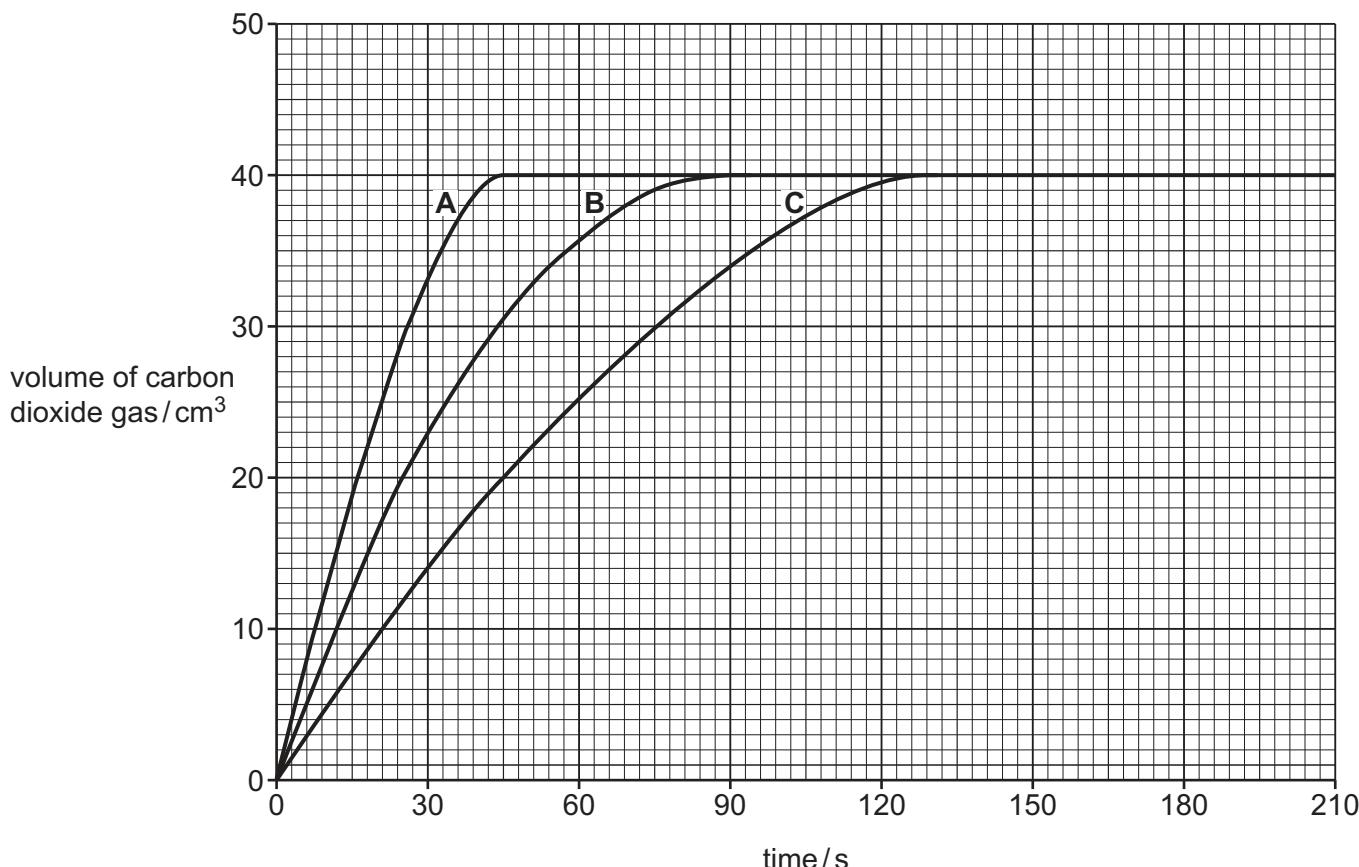


Fig. 5.1

(a) (i) State which marble chips, **A**, **B** or **C**, are the **smallest**.

.....

[1]

(ii) Look at the line for marble chips **B**.

State when the rate of reaction is the **greatest**.

Choose your answer from the list.

0 – 30 s

30 – 60 s

60 – 90 s

90 – 120 s

answer = s [1]

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(b) The students did the experiments at 20 °C.

State how the rate of reaction will change if they do the experiments again at 40 °C.

Explain your answer using ideas about collisions between particles.

.....
.....
.....
.....
.....

[3]

(c) Calculate the volume occupied by 1.1g of carbon dioxide gas at room temperature and pressure.

The volume of one mole of any gas is 24 dm³ at room temperature and pressure (r.t.p.).

[A_r: C, 12; O, 16]

volume of carbon dioxide gas = dm³ [3]

(d) Carbon dioxide is a greenhouse gas.

State **two** problems caused by increased concentrations of greenhouse gases.

1

.....

2

.....

[2]

[Total: 10]





6 Fig. 6.1 shows an electric pressure-washer being used to wash a car.

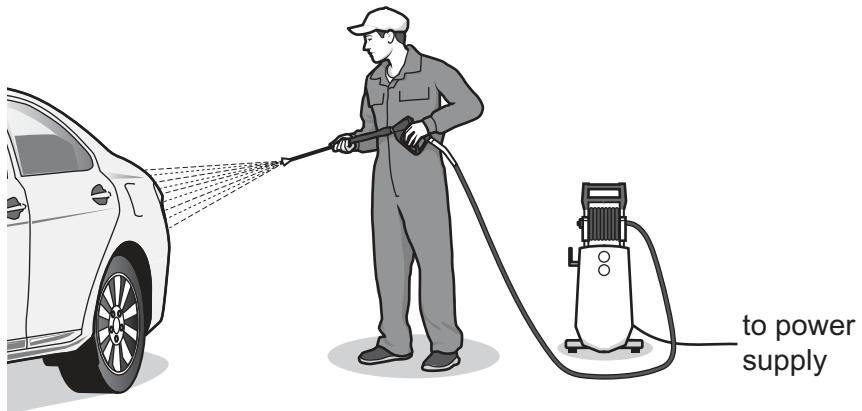


Fig. 6.1

(a) The pressure-washer pumps water at a high pressure through a small nozzle.

The cross-sectional area of the nozzle is $5.0 \times 10^{-6} \text{ m}^2$.

The water leaves the nozzle with a pressure of $9.0 \times 10^6 \text{ Pa}$.

Calculate the force exerted by the water as it leaves the nozzle.

force = N [2]





(b) The pressure-washer uses a d.c. motor to pump the water out of the nozzle.

Fig. 6.2 shows a diagram of a simple d.c. motor.

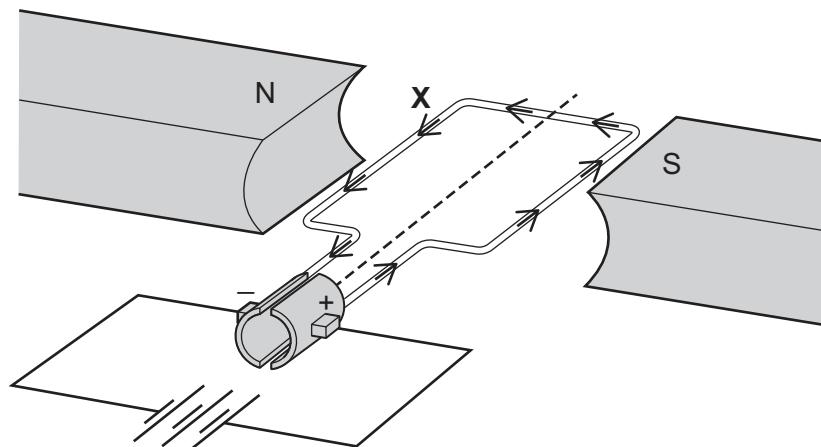


Fig. 6.2

(i) The arrows on Fig. 6.2 show the direction of the current.

Draw an arrow to show the direction of the force acting on the coil at the point labelled X. [1]

(ii) Describe the function of the split-ring commutator in a simple d.c. motor.

.....
.....
.....
.....

[2]

(c) After the car has been washed, droplets of cold water remain on the roof of the car.

After a few minutes, the droplets of water have disappeared.

(i) State the name of the process which causes the droplets of water to disappear.

..... [1]

(ii) Describe the process which causes the droplets of water to disappear in terms of molecules.

.....
.....
.....

[2]

[Total: 8]





7 (a) A student investigates antibiotic resistance in one strain of bacteria.

They use five different antibiotics on paper discs.

The antibiotic discs are placed in a Petri dish with the bacteria and left for three days.

Fig. 7.1 shows the results.

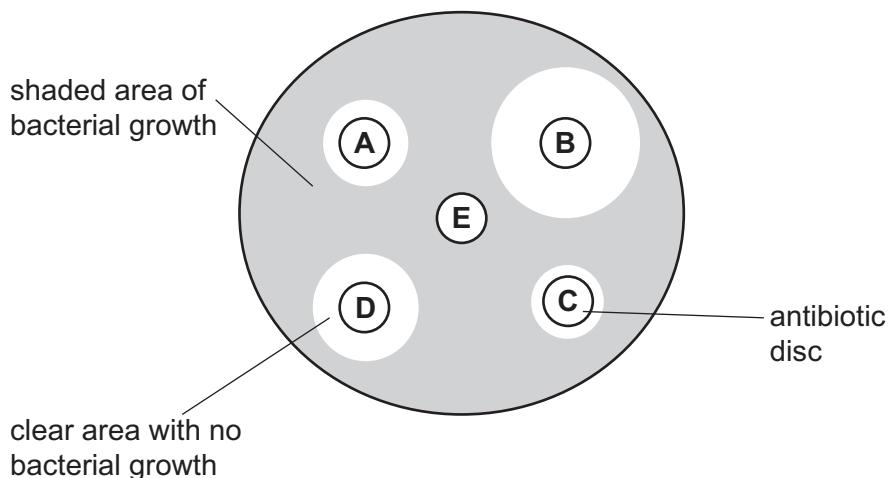


Fig. 7.1

Identify the antibiotic in Fig. 7.1 that is **most** effective against this strain of bacteria.

Give **one** reason for your answer.

antibiotic

reason

[2]

(b) The differences in antibiotic resistance in bacteria are caused by random mutation.

(i) State the structure in a cell where mutation occurs.

..... [1]

(ii) State the type of radiation that increases the rate of mutation.

..... [1]





(c) Explain why the development of antibiotic resistance in bacteria is an example of evolution.

.....

.....

.....

.....

.....

[2]

[Total: 6]

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8 Fig. 8.1 shows the structures of three carbon compounds.

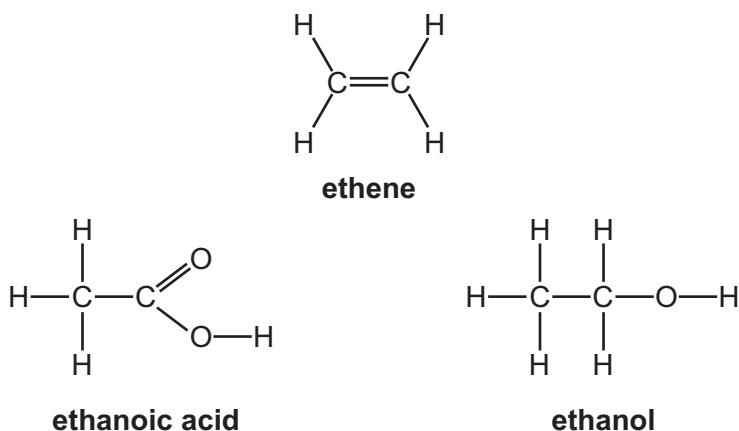


Fig. 8.1

(a) Ethene is an **unsaturated hydrocarbon**.

Explain how the structure of ethene shows that ethene is an unsaturated hydrocarbon.

unsaturated

.....

hydrocarbon

.....

[2]

(b) Ethene, C_2H_4 , reacts with hydrogen to make an alkane.

Write the balanced symbol equation for this reaction.

..... [2]

(c) Complete the dot-and-cross diagram in Fig. 8.2 to show the bonding in ethene.

Only show the outer-shell electrons.

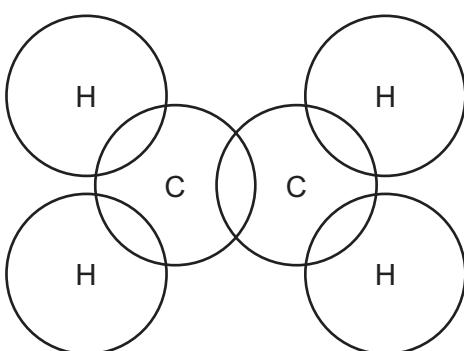


Fig. 8.2

[2]





(d) Ethanol is made by fermentation.

State **one** condition for making ethanol by fermentation.

..... [1]

(e) Ethanol can also be made from ethene in an addition reaction.

Complete the symbol equation for this reaction.



[1]

(f) A scientist makes a solution of ethanol.

250 cm³ of the solution contains 5.75 g of ethanol.

Calculate the concentration of the ethanol solution in **mol/dm³**.

[A_r: C, 12; H, 1; O, 16]

concentration of ethanol solution = mol/dm³ [4]

[Total: 12]





9 The element strontium has many naturally occurring isotopes, some of which are unstable.

(a) Table 9.1 shows the half-lives of four unstable isotopes of strontium.

Table 9.1

isotope	half-life
strontium-82	25.4 days
strontium-83	1.35 days
strontium-85	64.8 days
strontium-90	28.9 years

(i) Fig. 9.1 shows a decay curve for one of the isotopes given in Table 9.1.

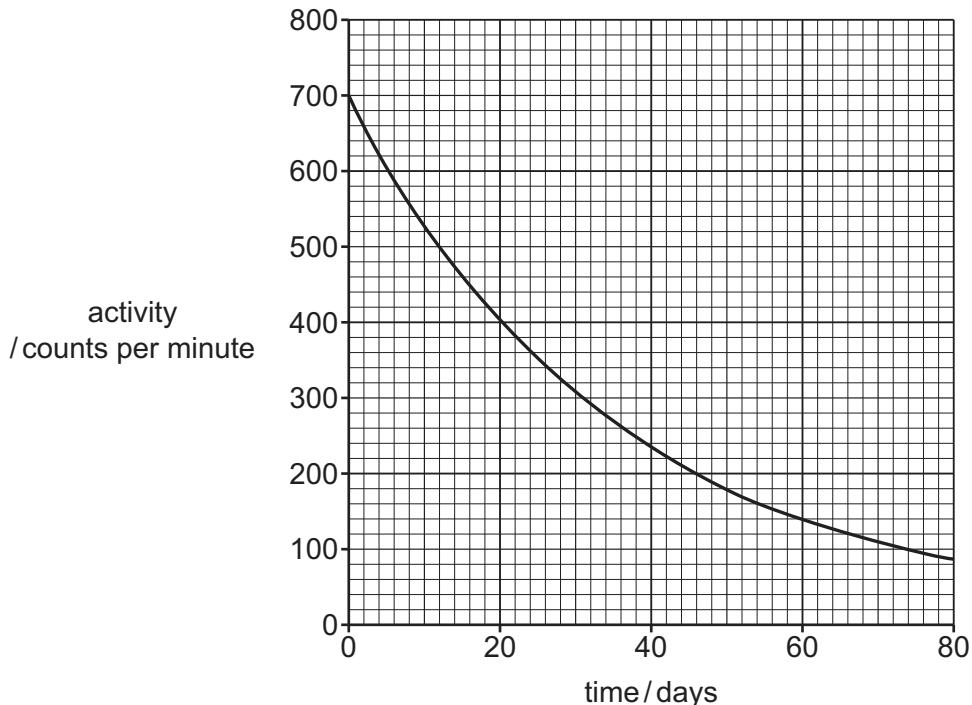


Fig. 9.1

Determine which isotope of strontium from Table 9.1 would give the data shown in Fig. 9.1.

isotope [2]





(ii) A scientist purchases a sample of a strontium isotope to use as a radioactive source in a series of experiments.

The scientist estimates that the experiments will take three months to complete.

Suggest which of the isotopes in Table 9.1 would be best for the scientist to purchase.

Explain your suggestion.

isotope

explanation

.....

[1]

(b) Place ticks (✓) in Table 9.2 to show the nature of a beta particle.

Table 9.2

has a positive charge	
has a negative charge	
has no charge	
is affected by electric fields	
is affected by magnetic fields	
is not affected by electric or magnetic fields	

[2]

(c) The density of strontium is 2.6 g/cm^3 .

A sample of strontium has a mass of 7.8g.

Calculate the volume of the sample of strontium.

volume = cm^3 [2]

[Total: 7]





10 (a) Red blood cells are specialised to transport oxygen.

Describe **two** ways that red blood cells are adapted for their function.

1

.....

2

.....

[2]

(b) A student investigates the effect of different concentrations of salt solution on red blood cells.

The student immerses the red blood cells in different concentrations of salt solution and observes the cells after immersion.

Table 10.1 shows the results.

Table 10.1

concentration of salt solution g/dm ³	observation
10.0	cells shrink
8.0	no change
6.0	cells burst
4.0	cells burst
2.0	cells burst

(i) Identify the salt solution with the same water potential as red blood cells.

..... g/dm³ [1]

(ii) Explain the observation seen at 10.0 g/dm³ in Table 10.1.

.....

.....

.....

.....

.....

.....

.....

[3]





(c) The investigation is repeated with plant cells.

(i) Plants cells do **not** burst when immersed in 2.0 g/dm^3 salt solution.

Explain why.

.....
.....
.....
.....
.....

[2]

(ii) State **two** uses of water in plant cells.

1

2

[2]

(iii) State the name of the type of plant cell specialised for absorption of water.

.....

[1]

[Total: 11]





11 Sulfuric acid is made by the Contact process.

Fig. 11.1 shows part of the Contact process.

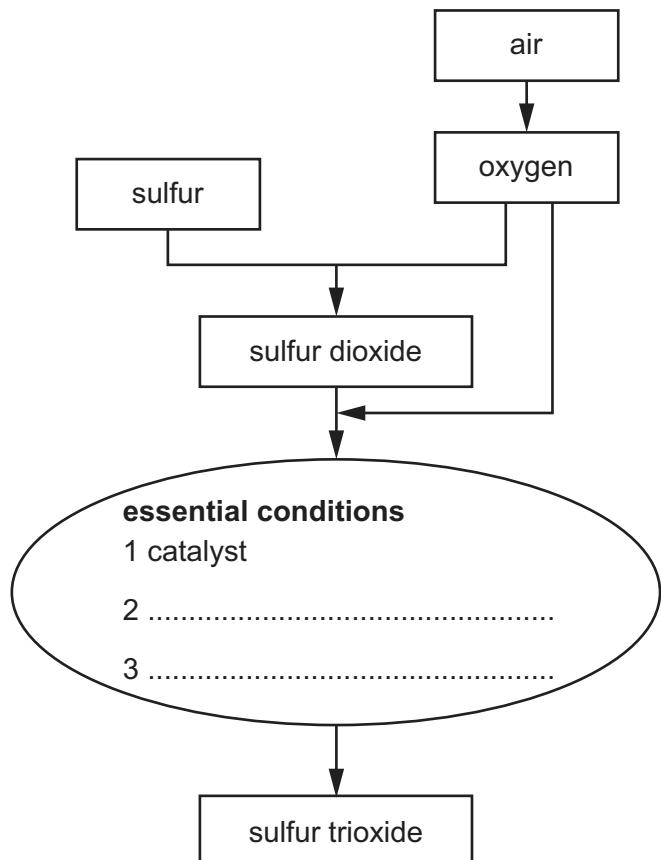


Fig. 11.1

(a) A catalyst is used in the Contact process.

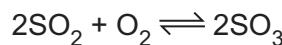
Complete Fig. 11.1 to show the **two** other essential conditions used.

[2]





(b) In the Contact process, sulfur dioxide, SO_2 , reacts with oxygen, O_2 , to make sulfur trioxide, SO_3 .



(i) Calculate the maximum mass of sulfur trioxide that is made from 1.6 kg of sulfur dioxide.

[A_r : O, 16; S, 32]

mass of sulfur trioxide = kg [3]

(ii) Fig. 11.2 shows the energy level diagram for the reaction to make sulfur trioxide.

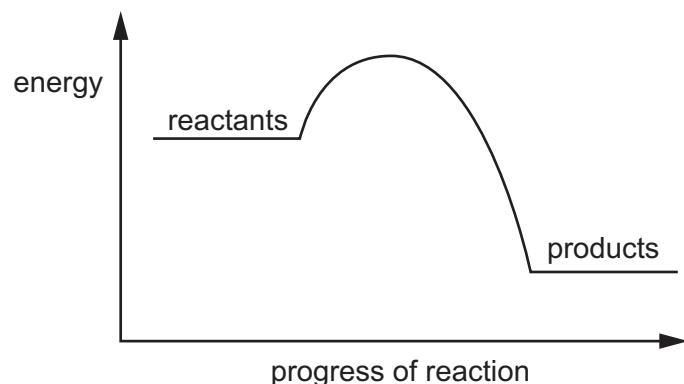


Fig. 11.2

Draw and label on Fig. 11.2:

- the energy change in the reaction
- the activation energy of the reaction.

[2]

[Total: 7]





12 Electricity can be generated in different types of power stations.

(a) Table 12.1 gives some information about six types of power station.

Table 12.1

type of power station	energy per kg of fuel / MJ	efficiency of transfer to electrical energy / %	percentage of world electricity production
coal	29	32	37
hydroelectric (HEP)	–	90	15
natural gas	45	49	24
nuclear	5.0×10^5	93	10
solar	–	21	9
wind	–	40	5

(i) Use data from Table 12.1 to explain why electricity generation is negatively impacting the environment.

.....

 [3]

(ii) Nuclear power stations are very expensive to build.

Apart from cost, state **one** advantage and **one** disadvantage of generating electricity using wind compared to nuclear.

advantage

.....

disadvantage

..... [2]

(iii) Use data from Table 12.1 to calculate the mass of natural gas needed to generate the same electrical energy output as 1 kg of nuclear fuel.

mass = kg [3]





(b) A coal power station generates electricity at a voltage of 25 000 V.

A transformer is used to step the voltage up to 132 000 V for transmission.

(i) The step-up transformer contains 3000 turns on the primary coil.

Calculate the number of turns on the secondary coil.

number of turns = [2]

(ii) Explain why electricity is transmitted at a voltage of 132 000 V and **not** 25 000 V.

.....

 [2]

[Total: 12]

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The Periodic Table of Elements

		Group																	
I	II	Key			III			IV			V			VI			VII		
3	Li	4	Be	hydrogen 1	H	5	B	6	C	7	N	8	O	9	F	10	2	He	
						5	B	6	C	7	N	8	O	9	F	10	2	He	
3	Li	4	Be	hydrogen 1	H	5	Boron 11	6	Carbon 12	7	Nitrogen 14	8	Oxygen 16	9	Fluorine 19	10	Neon 20	2	He
7	lithium	9	beryllium	1		11	boron	12	carbon	13	nitrogen	14	oxygen	15	fluorine	16	neon	20	He
11	Na	12	Mg	magnesium 24		12	Aluminum 27	13	Silicon 28	14	Phosphorus 31	15	Sulfur 32	16	Chlorine 35.5	17	Argon 40	18	Ar
19	K	20	Ca	calcium 40		21	Scandium 45	22	Titanium 48	23	Vanadium 51	24	Chromium 52	25	Manganese 55	26	Iron 56	27	Co
39	potassium	39	Ca	calcium 40		40	Sc	41	Ti	42	V	43	Cr	44	Mn	45	Fe	46	Co
37	Rb	38	Sr	strontium 88		39	Y	40	Zr	41	Titanium 48	42	Nb	43	Mo	44	Rh	45	Pd
85	rubidium	85	Sr	strontium 88		89	Yttrium 91	90	Zirconium 91	91	Niobium 93	92	Tantalum 101	93	Molybdenum 96	94	Ruthenium 103	95	Ag
55	Cs	56	Ba	barium 137		57-71	Lanthanoids	72	Hf	73	Ta	74	Re	75	Os	76	Pt	77	Ir
133	cassium	133	Ba	barium 137		137	lanthanoids	178	Hafnium 178	181	Tantalum 181	184	Rhenium 186	184	Osmium 190	192	Platinum 195	197	Au
87	Fr	88	Ra	radium -		89-103	Actinoids	104	Rf	105	Db	106	Sg	107	Bh	108	Rs	109	Mt
-	francium	-	Ra	radium -		-	actinoids	-	Rutherfordium	-	Dubnium	-	Seaborgium	-	Hassium	-	Roentgenium	-	Moscovium
57	La	58	Ce	cerium 140		59	Pr	60	Nd	61	Pm	62	Sm	63	Eu	64	Gd	65	Tb
139	lanthanum	139	Ce	cerium 140		141	Praseodymium 141	144	Neodymium 144	145	Promethium 145	150	Samarium 150	152	Europium 152	157	Gadolinium 157	159	Terbium 159
89	Th	90	Pa	Protactinium 231		91	U	92	Np	93	Am	94	Pu	95	Americium 238	96	Cm	97	Bk
-	actinium	-	Th	Protactinium 231		-	Thorium 232	-	Neptunium 238	-	Rutherfordium	-	Plutonium 238	-	Curium 240	-	Curium 240	-	Berkelium 240
57	La	58	Ce	cerium 140		59	Pr	60	Nd	61	Pm	62	Sm	63	Eu	64	Gd	65	Dy
139	lanthanum	139	Ce	cerium 140		141	Praseodymium 141	144	Neodymium 144	145	Promethium 145	150	Samarium 150	152	Europium 152	157	Gadolinium 157	159	Terbium 159
89	Th	90	Pa	Protactinium 231		91	U	92	Np	93	Am	94	Pu	95	Americium 238	96	Cm	97	Bk
-	actinium	-	Th	Protactinium 231		-	Thorium 232	-	Neptunium 238	-	Rutherfordium	-	Plutonium 238	-	Curium 240	-	Curium 240	-	Berkelium 240
57	La	58	Ce	cerium 140		59	Pr	60	Nd	61	Pm	62	Sm	63	Eu	64	Gd	65	Tb
139	lanthanum	139	Ce	cerium 140		141	Praseodymium 141	144	Neodymium 144	145	Promethium 145	150	Samarium 150	152	Europium 152	157	Gadolinium 157	159	Terbium 159
89	Th	90	Pa	Protactinium 231		91	U	92	Np	93	Am	94	Pu	95	Americium 238	96	Cm	97	Bk
-	actinium	-	Th	Protactinium 231		-	Thorium 232	-	Neptunium 238	-	Rutherfordium	-	Plutonium 238	-	Curium 240	-	Curium 240	-	Berkelium 240
57	La	58	Ce	cerium 140		59	Pr	60	Nd	61	Pm	62	Sm	63	Eu	64	Gd	65	Dy
139	lanthanum	139	Ce	cerium 140		141	Praseodymium 141	144	Neodymium 144	145	Promethium 145	150	Samarium 150	152	Europium 152	157	Gadolinium 157	159	Terbium 159
89	Th	90	Pa	Protactinium 231		91	U	92	Np	93	Am	94	Pu	95	Americium 238	96	Cm	97	Bk
-	actinium	-	Th	Protactinium 231		-	Thorium 232	-	Neptunium 238	-	Rutherfordium	-	Plutonium 238	-	Curium 240	-	Curium 240	-	Berkelium 240
57	La	58	Ce	cerium 140		59	Pr	60	Nd	61	Pm	62	Sm	63	Eu	64	Gd	65	Tb
139	lanthanum	139	Ce	cerium 140		141	Praseodymium 141	144	Neodymium 144	145	Promethium 145	150	Samarium 150	152	Europium 152	157	Gadolinium 157	159	Terbium 159
89	Th	90	Pa	Protactinium 231		91	U	92	Np	93	Am	94	Pu	95	Americium 238	96	Cm	97	Bk
-	actinium	-	Th	Protactinium 231		-	Thorium 232	-	Neptunium 238	-	Rutherfordium	-	Plutonium 238	-	Curium 240	-	Curium 240	-	Berkelium 240
57	La	58	Ce	cerium 140		59	Pr	60	Nd	61	Pm	62	Sm	63	Eu	64	Gd	65	Dy
139	lanthanum	139	Ce	cerium 140		141	Praseodymium 141	144	Neodymium 144	145	Promethium 145	150	Samarium 150	152	Europium 152	157	Gadolinium 157	159	Terbium 159
89	Th	90	Pa	Protactinium 231		91	U	92	Np	93	Am	94	Pu	95	Americium 238	96	Cm	97	Bk
-	actinium	-	Th	Protactinium 231		-	Thorium 232	-	Neptunium 238	-	Rutherfordium	-	Plutonium 238	-	Curium 240	-	Curium 240	-	Berkelium 240
57	La	58	Ce	cerium 140		59	Pr	60	Nd	61	Pm	62	Sm	63	Eu	64	Gd	65	Tb
139	lanthanum	139	Ce	cerium 140		141	Praseodymium 141	144	Neodymium 144	145	Promethium 145	150	Samarium 150	152	Europium 152	157	Gadolinium 157	159	Terbium 159
89	Th	90	Pa	Protactinium 231		91	U	92	Np	93	Am	94	Pu	95	Americium 238	96	Cm	97	Bk
-	actinium	-	Th	Protactinium 231		-	Thorium 232	-	Neptunium 238	-	Rutherfordium	-	Plutonium 238	-	Curium 240	-	Curium 240	-	Berkelium 240
57	La	58	Ce	cerium 140		59	Pr	60	Nd	61	Pm	62	Sm	63	Eu	64	Gd	65	Tb
139	lanthanum	139	Ce	cerium 140		141	Praseodymium 141	144	Neodymium 144	145	Promethium 145	150	Samarium 150	152	Europium 152	157	Gadolinium 157	159	Terbium 159
89	Th	90	Pa	Protactinium 231		91	U	92	Np	93	Am	94	Pu	95	Americium 238	96	Cm	97	Bk
-	actinium	-	Th	Protactinium 231		-	Thorium 232	-	Neptunium 238	-	Rutherfordium	-	Plutonium 238	-	Curium 240	-	Curium 240	-	Berkelium 240
57	La	58	Ce	cerium 140		59	Pr	60	Nd	61	Pm	62	Sm	63	Eu	64	Gd	65	Tb
139	lanthanum	139	Ce	cerium 140		141	Praseodymium 141	144	Neodymium 144	145	Promethium 145	150	Samarium 150	152	Europium 152	157	Gadolinium 157	159	Terbium 159
89	Th	90	Pa	Protactinium 231		91	U	92	Np	93	Am	94	Pu	95	Americium 238	96	Cm	97	Bk
-	actinium	-	Th	Protactinium 231		-	Thorium 232	-	Neptunium 238	-	Rutherfordium	-	Plutonium 238	-	Curium 240	-	Curium 240	-	Berkelium 240
57	La	58	Ce	cerium 140		59	Pr	60	Nd	61	Pm	62	Sm	63	Eu	64	Gd	65	Tb
139	lanthanum	139	Ce	cerium 140		141	Praseodymium 141	144	Neodymium 144	145	Promethium 145	150	Samarium 150	152	Europium 152	157	Gadolinium 157	159	Terbium 159
89	Th	90	Pa	Protactinium 231		91	U	92	Np	93	Am	94	Pu	95	Americium 238	96	Cm	97	Bk
-	actinium	-	Th	Protactinium 231		-	Thorium 232	-	Neptunium 238	-	Rutherfordium	-	Plutonium 238	-	Curium 240	-	Curium 240	-	Berkelium 240
57	La	58	Ce	cerium 140		59	Pr	60	Nd	61	Pm	62	Sm	63	Eu	64	Gd	65	Tb
139	lanthanum	139	Ce	cerium 140		141	Praseodymium 141	144	Neodymium 144	145	Promethium 145	150	Samarium 150	152	Europium 152	157	Gadolinium 157	159	Terbium 159
89	Th	90	Pa	Protactinium 231		91	U	92	Np	93	Am	94	Pu	95	Americium 238	96	Cm	97	Bk
-	actinium	-	Th	Protactinium 231		-	Thorium 232	-	Neptunium 238	-	Rutherfordium	-	Plutonium 238	-	Curium 240	-	Curium 240	-	Berkelium 240
57	La	58	Ce	cerium 140		59	Pr	60	Nd	61	Pm	62	Sm	63	Eu	64	Gd	65	Tb
139	lanthanum	139	Ce	cerium 140		141	Praseodymium 141	144	Neodymium 144	145	Promethium 145	150	Samarium 150	152	Europium 152	157	Gadolinium 157	159	Terbium 159
89	Th	90	Pa	Protactinium 231		91	U	92	Np	93	Am	94	Pu	95	Americium 238	96	Cm	97	Bk
-	actinium	-	Th	Protactinium 231		-	Thorium 232	-	Neptunium 238	-	Rutherfordium	-	Plutonium 238	-	Curium 240	-	Curium 240	-	Berkelium 240
57	La	58	Ce	cerium 140		59	Pr	60	Nd	61	Pm	62	Sm	63	Eu	64	Gd	65	Tb
139	lanthanum	139	Ce	cerium 140		141	Praseodymium 141	144	Neodymium 144	145	Promethium 145	150	Samarium 150	152	Europium 152	157	Gadolinium 157	159	Terbium 159
89	Th	90	Pa	Protactinium 231		91	U	92	Np	93	Am	94	Pu	95	Americium 238	96	Cm	97	Bk
-	actinium	-	Th	Protactinium 231		-	Thorium 232	-	Neptunium 238	-	Rutherfordium	-	Plutonium 238	-	Curium 240	-	Curium 240	-	Berkelium 240
57	La	58	Ce	cerium 140		59	Pr	60	Nd	61	Pm	62	Sm	63	Eu	64	Gd	65	Tb
139	lanthanum	139	Ce	cerium 140		141	Praseodymium 141	144	Neodymium 144	145	Promethium 145	150	Samarium 150	152	Europium 152	157	Gadolinium 157	159	Terbium 159
89	Th	90	Pa	Protactinium 231		91	U	92	Np	93	Am	94	Pu	95	Americium 238	96	Cm	97	Bk
-	actinium	-	Th	Protactinium 231		-	Thorium 232	-	Neptunium 238	-	Rutherfordium	-	Plutonium 238	-	Curium 240	-	Curium 240	-	Berkelium 240
57	La	58	Ce	cerium 140		59	Pr	60	Nd	61	Pm	62	Sm	63	Eu	64	Gd	65	Tb
139	lanthanum	139	Ce	cerium 140		141	Praseodymium 141	144	Neodymium 144	145	Promethium 145	150	Samarium 150	152	Europium 152	157	Gadolinium 157	159	Terbium 159
89	Th	90	Pa	Protactinium 231		91	U	92	Np	93	Am	94	Pu	95	Americium 238	96	Cm	97	Bk
-	actinium	-	Th	Protactinium 231		-	Thorium 232	-	Neptunium 238	-	Rutherfordium	-	Plutonium 238	-	Curium 240	-	Curium 240	-	Berkelium 240
57	La																		

The volume of one mole of any gas is 24 dm^3 at room temperature and pressure (r.t.p.).