OCR
Oxford Cambridge and RSA

Level 3 Cambridge Technical in Laboratory Skills
05847/05848/05849/05874/05879

Unit 2: Laboratory techniques

Friday 12 January 2018 – Morning
Time allowed: 2 hours

You must have:
- a ruler

You may use:
- a scientific or graphical calculator

First Name		Last Name	

Centre Number						Candidate Number				

Date of Birth	D	D	M	M	Y	Y	Y	Y

INSTRUCTIONS
- Use black ink.
- Complete the boxes above with your name, centre number, candidate number and date of birth.
- Answer **all** the questions.
- Write your answer to each question in the space provided.
- If additional answer space is required, you should use the lined page(s) at the end of this booklet. The question number(s) must be clearly shown.
- The Periodic Table is printed on the back page.

INFORMATION
- The total mark for this paper is **90**.
- The marks for each question are shown in brackets **[ ]**.
- This document consists of **24** pages.

FOR EXAMINER USE ONLY	
Question No	**Mark**
1	/15
2	/15
3	/15
4	/14
5	/15
6	/16
Total	**/90**

Answer **all** the questions.

1 Middle East Respiratory Syndrome (MERS-CoV) is a disease of the respiratory system.

MERS-CoV is caused by a new strain of a virus called a coronavirus.

(a) The virus has been transmitted from infected patients to other patients and workers within hospitals.

Suggest **two** ways in which the transmission of the virus could be reduced in hospitals.

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2 .....

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[2]

(b) In 2014 it emerged that camels in the Middle East were the main source of the virus.

The link to camels was established when scientists analysed blood samples from infected camels.

(i) Suggest **two** precautions the scientists should take when they are taking blood samples from camels.

1 .....

2 .....

[2]

(ii) Suggest **two** precautions the scientists should take when they are analysing blood samples that may be contaminated with microorganisms.

1 .....

2 .....

[2]

(c) The virus is thought to have been infecting camels since 1992.

Blood samples collected from camels have been stored since 1992. These have now been analysed for evidence of the virus, and to see if the virus has changed.

(i) Scientists are planning to compare the information about the virus found in blood samples taken in 1992 with that from blood samples taken in 2014.

Explain how the scientists could ensure the comparisons of the 1992 and 2014 viruses are valid.

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.....**[2]**

(ii) Suggest how the blood samples from 1992 would have been stored and explain why they were stored in such a way.

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.....**[3]**

(d) The DNA of disease-causing (pathogenic) microorganisms in tissue samples is often analysed.

(i) Suggest why tissue samples are sent to specific laboratories rather than analysed in laboratories in their country of origin.

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.....**[1]**

(ii) Describe **two** ways biological samples, such as tissue samples, are transported.

1 .....

2 .....

[2]

(iii) A laboratory receives tissue samples for analysis.

Identify the type of sample to be removed for analysis.

Put a tick (✓) in the box next to the correct answer.

random ☐

representative ☐

whole ☐

[1]

2 A DNA-sequencing laboratory in the UK receives tissue samples for analysis.

(a) Suggest **two** features of the DNA sample to be checked before sequencing.

1.....

2.....

[2]

(b) When DNA from tissue samples is analysed the DNA has to first be broken into fragments.

One of the next stages of analysis of DNA from tissue samples is the Polymerase Chain Reaction (PCR).

Describe **two** of the steps carried out during PCR.

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[2]

(c) The DNA fragments are then separated by gel electrophoresis.

(i) Describe how gel electrophoresis can be carried out in a school or college laboratory.

You may draw a diagram in the space below to help with your description of the process.

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.....**[4]**

(ii) Explain how gel electrophoresis separates the fragments of DNA.

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.....**[3]**

(d) DNA samples must contain the optimum amount of DNA for analysis.

The mass of the human genome is 6 picograms.

1000 picograms = 1 nanogram

The DNA-sequencing laboratory prepares samples for fragmentation containing

400 nanograms of DNA / 100 µl.

Calculate the number of complete genomes that are contained in a 1 µl fragmented sample.

Show your working.

number of complete genomes = ...

[3]

(e) State the name of an alternative technique that can be used to separate components within a mixture of DNA.

.....**[1]**

3 Scientists are finding out more about the use of algae as 'superfoods'.

(a) Scientists in India have recently analysed the composition of a blue-green alga called *Spirulina*.

The main elements found in *Spirulina* are shown in **Table 3.1**.

Element	**Concentration in *Spirulina* (mg of element 100 g^{-1} of alga)**
calcium	876
iron	29
magnesium	205
phosphorus	230
potassium	930
sodium	32

Table 3.1

(i) Some cations can be detected in samples using flame tests.

Describe the procedure followed to carry out a flame test on a sample of dried and powdered *Spirulina*.

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.....**[4]**

(ii) Complete **Table 3.2** to show the flame test results for the three cations listed.

Cation	**Colour in a flame**
calcium	
potassium	
sodium	

Table 3.2

[3]

(iii) Explain why a flame test could **not** be used to identify all of the elements in a sample of *Spirulina*.

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.....**[2]**

(b) The scientists use inductively–coupled plasma–atomic emission spectroscopy (ICP–AES) to carry out their analyses.

Explain the principles of this technique and the advantages of using this technique for the analysis of elements in a sample of *Spirulina*.

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.....**[6]**

4 Helena is a quality control scientist analysing the vitamin C content of a sample of liquid vitamin supplement.

(a) Vitamin C is a monoprotic acid. One way of estimating the concentration of vitamn C in a sample is by titrating against sodium hydroxide.

(i) The formula of vitamin C is $HC_6H_7O_6$.

Complete the balanced symbol equation for the reaction between vitamin C and sodium hydroxide.

…… + NaOH ⟶ $NaC_6H_7O_6$ + ……

[2]

(ii) The properties of some indicators are shown in **Table 4.1**.

Indicator	Colour change	pH range
bromophenol blue	yellow – blue	2.8 – 4.6
methyl red	red – yellow	4.2 – 6.3
bromothymol blue	yellow – blue	6.0 – 7.6
phenol red	yellow – red	6.8 – 8.4
thymol blue	yellow – blue	8.0 – 9.6

Table 4.1

Vitamin C is a weak acid and sodium hydroxide is a strong base.
Using this information, select the most appropriate indicator from **Table 4.1** for a titration of a sample containing vitamin C against sodium hydroxide solution.

Justify your selection.

Indicator .....

Justification .....

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[2]

(b) Helena begins to carry out the titration.

(i) She makes up a solution of sodium hydroxide and finds that its concentration is 0.2445 mol dm^{-3}.

Suggest how Helena finds the concentration of the sodium hydroxide solution.

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.....**[2]**

(ii) She measures out 5 cm^3 of the liquid vitamin supplement into a conical flask.

Name the piece of equipment Helena would use to measure out the liquid vitamin supplement.

Put a tick (✓) in the box next to the correct answer.

gas syringe ☐

graduated pipette ☐

beaker ☐

dropper ☐

[1]

(c) Helena's titration results are shown in **Table 4.2**.

	titration			
	rough	**1**	**2**	**3**
final reading (cm^3)	24.00	23.65	47.35	23.60
initial reading (cm^3)	0.00	0.00	23.65	0.00
volume of sodium hydroxide used (cm^3)				
average volume of sodium hydroxide used (cm^3)				

Table 4.2

(i) Complete **Table 4.2** by calculating:

- the volume of sodium hydroxide used for each titration
- the average volume of sodium hydroxide used.

[1]

(ii) Calculate the average number of moles of sodium hydroxide that reacted with the vitamin C in the liquid vitamin supplement.

Use the formula:
$n = c \times V$

c = concentration in mol dm^{-3}
n = number of moles
V = volume in dm^{-3}

Show your working.

average = …… moles
[3]

(iii) The molar mass of vitamin C is 176.12 g mol^{-1}.

Calculate the concentration of vitamin C in the liquid vitamin supplement.

Give your answer to **two** decimal places.

Show your working.

concentration = …… mg cm^{-3}
[3]

5 Forensic microscopy is often used in cases of industrial hygiene, environmental monitoring and forensic investigations.

(a) Steve is an industrial forensic technician.

He analyses the fumes produced during welding.

Steve examines deposits from the fumes with a transmission electron microscope. A number of soot particles are visible in the transmission electron micrographs.

(i) One of the transmission electron micrographs he produces is shown in **Fig. 5.1**.

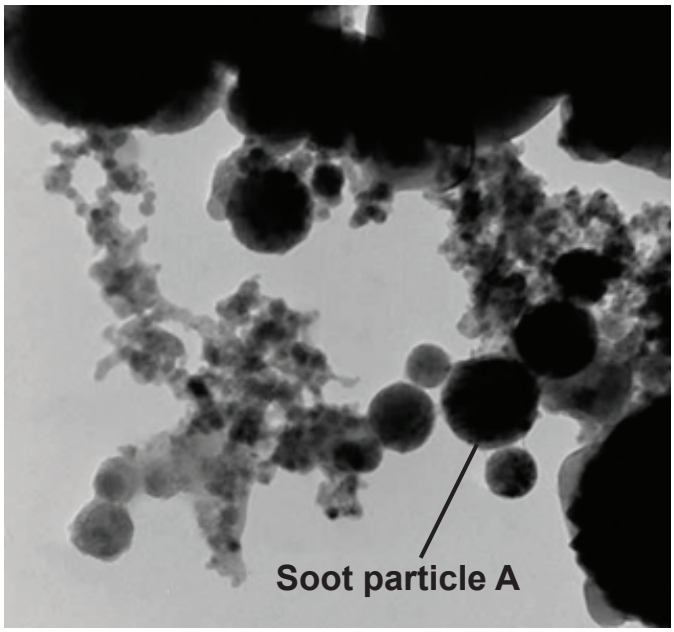

Fig. 5.1

The magnification of the micrograph shown in **Fig. 5.1** is ×120 000.

Calculate the diameter of **Soot particle A**.

Use the formula:

$$\text{magnification} = \frac{\text{measured size}}{\text{actual size}}$$

Show your working.

diameter = ... nm

[3]

(ii) Suggest **two** reasons why Steve uses a transmission electron microscopy (TEM), rather than other forms of microscopy.

1.....

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2.....

[2]

(b) A team of firefighters was exposed to dust clouds when tackling an industrial fire.

They were asked to provide sputum samples from their lower airways for analysis.

The samples were examined by Steve using scanning electron microscopy.

Fig. 5.2 shows a micrograph of a particle removed from one of the firefighter's lungs.

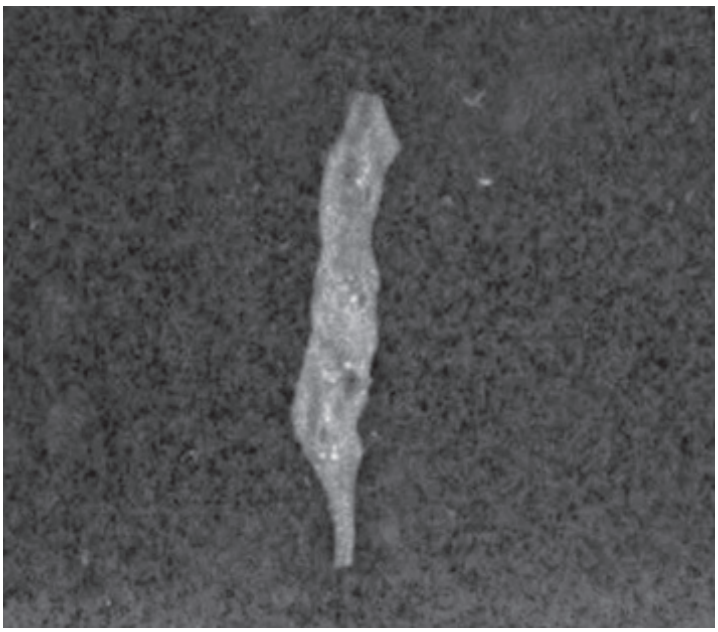

Fig. 5.2

(i) The length of the particle is 125 µm.

Draw a scale bar of appropriate length next to **Fig. 5.2**.

Show your working.

[4]

(ii) Some of the particles discovered were larger, metallic particles.

Explain how a different type of microscopical technique could be used to view these.

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.....**[2]**

(c) Healthcare professionals monitored the health of the firefighters' nine months after the industrial fire.

Figure 5.3 is a stained light micrograph of white blood cells in the sputum of a firefighter.

One of the white blood cells contains particles of dust.

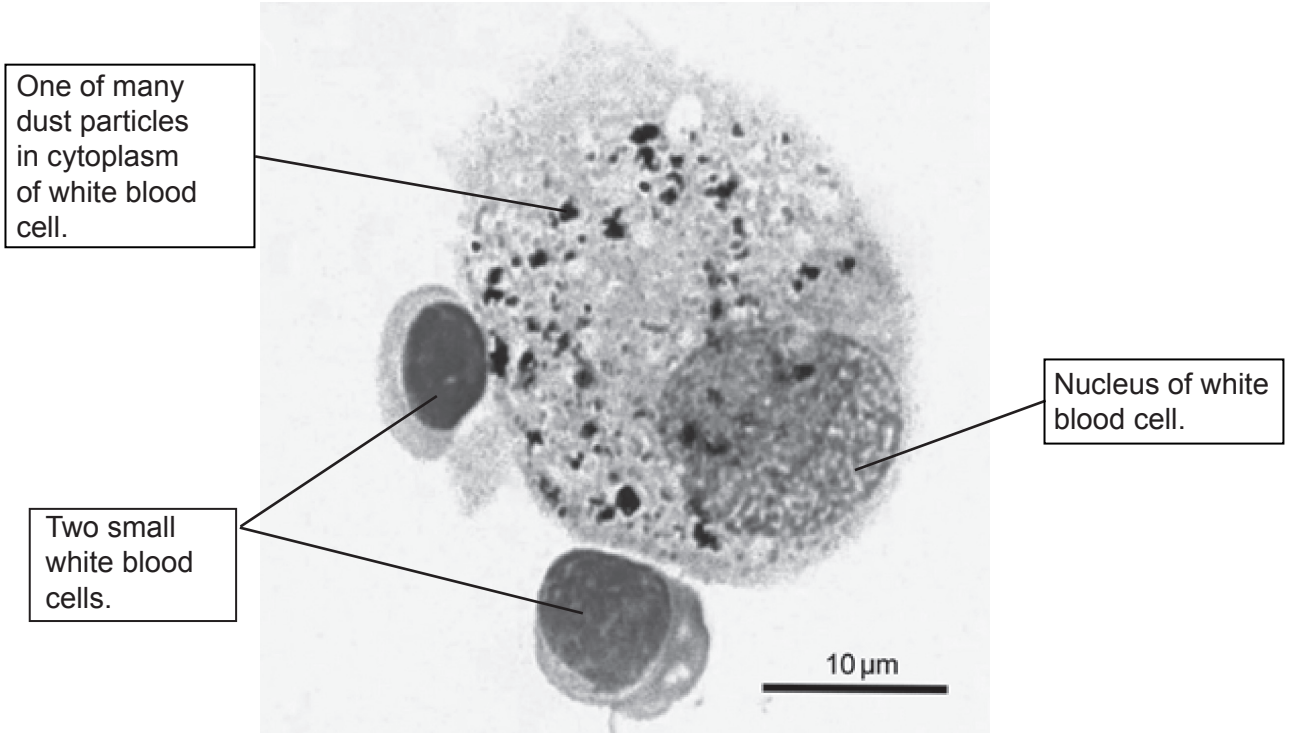

Figure 5.3

Explain why, in this instance, light microscopy was preferred to other forms of microscopy.

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.....**[2]**

(d) The level of detail in an image depends on the resolving power of the microscope.

The theoretical resolving power of an objective lens of a light microscope can be calculated using the following equation:

$$\varepsilon = 0.61 \times \frac{\lambda}{N.A.}$$

ε = resolving power, in micrometres (μm)

λ = the wavelength of light, in μm. Assume this to be 0.55 μm

$N.A.$ = the Numerical Aperture of the lens

For a lens with a $N.A.$ of 0.90, calculate its theoretical resolving power.

resolving power = ... μm

[2]

6 Polyethylene terephthalate (PET) is a plastic often described by polymer chemists as indestructible. PET is very slow to biodegrade.

In 2016, scientists discovered a soil bacterium, called *Ideonella sakaiensis*. This bacterium is able to live on the surface of, and biodegrade, PET.

The bacterium, along with other soil-living bacteria, is shown on the surface of a waste PET bottle in **Fig. 6.1**.

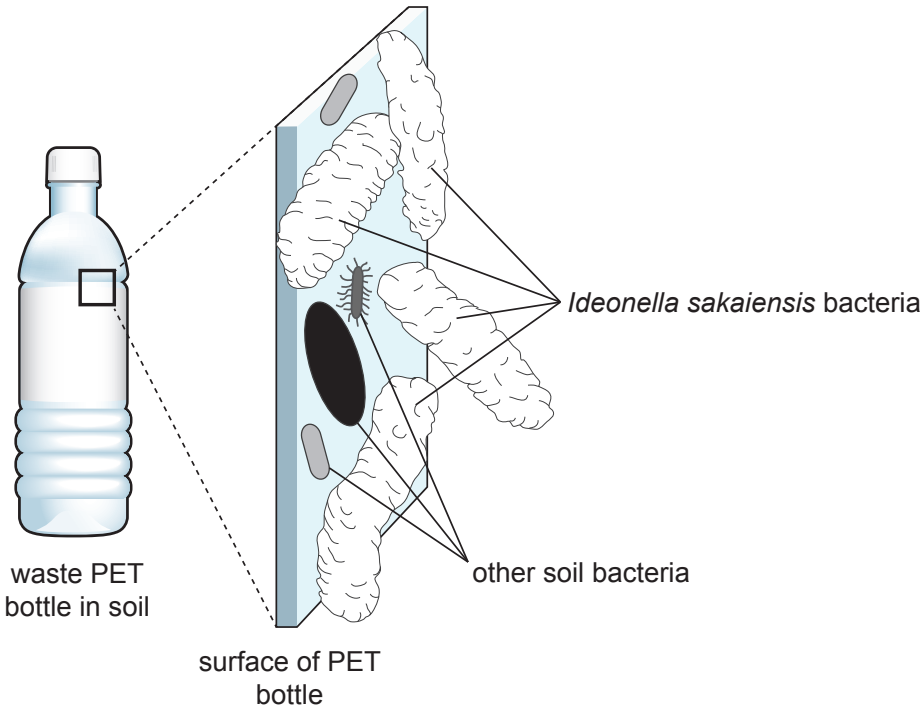

Fig. 6.1

(a) You are given a waste PET bottle known to have *Ideonella sakaiensis* on its surface.

Describe in detail how aseptic techniques could be used to prepare a pure culture of the bacterium *Ideonella sakaiensis* in the laboratory.

Assume that *Ideonella sakaiensis* is the bacterium likely to be in the highest concentration on the bottle.

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.....**[6]**

(b) Aseptic technique is essential in all microbiological work.

(i) Give **two** reasons for the importance of aseptic technique.

1 .....

2 .....
[2]

(ii) Give **two** other examples of laboratory work, other than culturing bacteria, in which the use of aseptic technique is essential.

1 .....

2 .....
[2]

(c) Describe how the waste PET bottle, along with other waste, is treated after isolating the bacterium from its surface.

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.....**[2]**

(d) Scientists in another lab prepare a liquid culture of the bacterium.

They use a counting chamber and a microscope to estimate the concentration of the bacterial cells in the liquid culture.

The surface of the counting chamber is shown in **Fig. 6.2**.

The chamber has a (0.05mm × 0.05mm × 0.10 mm) volume of liquid culture beneath each of the smallest squares.

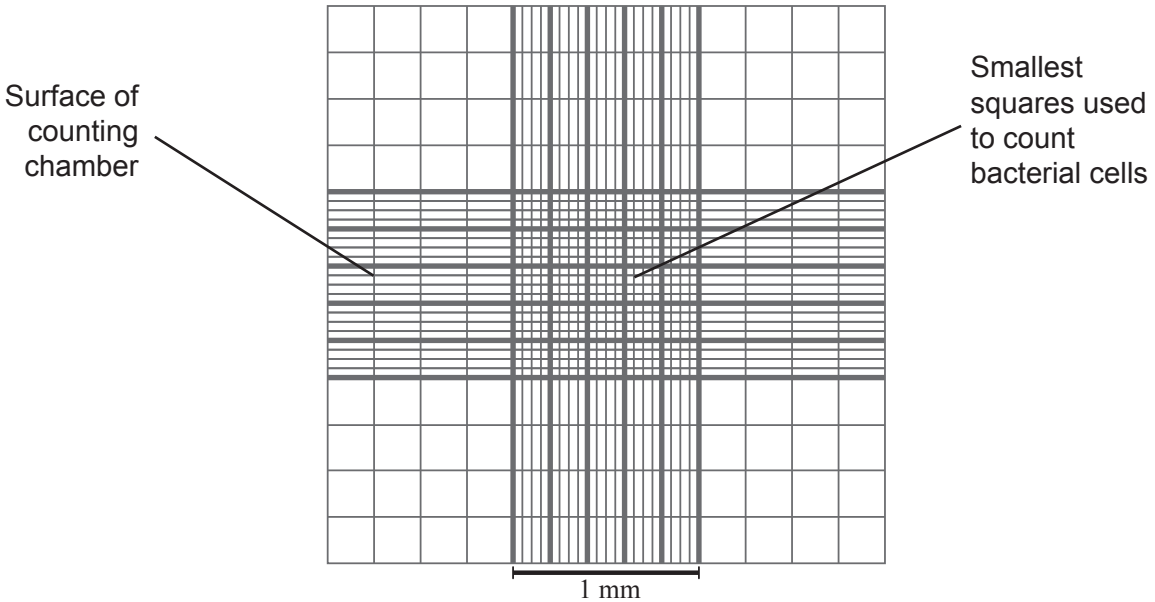

Fig. 6.2

The results of the cell counts for 10 of the smallest squares are shown in **Table 6.1**.

Cell count (0.05 mm × 0.05 mm × 0.10 mm square)											
Replicate	1	3	3	4	5	6	7	8	9	10	Mean cell count
Cell count recorded	50	48	48	52	49	53	52	50	49	51	

Table 6.1

(i) Calculate the mean cell count and complete **Table 6.1**.

[1]

(ii) Calculate the concentration of bacterial cells in the liquid culture.

Show your working and include the units.

concentration = …….. (units) ……..

[3]

END OF QUESTION PAPER

ADDITIONAL ANSWER SPACE

If additional answer space is required, you should use the following lined page(s). The question number(s) must be clearly shown in the margin(s) – for example 1(d) or 4(c).

The Periodic Table of the Elements

Key
atomic number
Symbol
name
relative atomic mass

(1)	(2)											(3)	(4)	(5)	(6)	(7)	(0)
1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**
1 **H** hydrogen 1.0																	2 **He** helium 4.0
3 **Li** lithium 6.9	4 **Be** beryllium 9.0											5 **B** boron 10.8	6 **C** carbon 12.0	7 **N** nitrogen 14.0	8 **O** oxygen 16.0	9 **F** fluorine 19.0	10 **Ne** neon 20.2
11 **Na** sodium 23.0	12 **Mg** magnesium 24.3											13 **Al** aluminium 27.0	14 **Si** silicon 28.1	15 **P** phosphorus 31.0	16 **S** sulfur 32.1	17 **Cl** chlorine 35.5	18 **Ar** argon 39.9
19 **K** potassium 39.1	20 **Ca** calcium 40.1	21 **Sc** scandium 45.0	22 **Ti** titanium 47.9	23 **V** vanadium 50.9	24 **Cr** chromium 52.0	25 **Mn** manganese 54.9	26 **Fe** iron 55.8	27 **Co** cobalt 58.9	28 **Ni** nickel 58.7	29 **Cu** copper 63.5	30 **Zn** zinc 65.4	31 **Ga** gallium 69.7	32 **Ge** germanium 72.6	33 **As** arsenic 74.9	34 **Se** selenium 79.0	35 **Br** bromine 79.9	36 **Kr** krypton 83.8
37 **Rb** rubidium 85.5	38 **Sr** strontium 87.6	39 **Y** yttrium 88.9	40 **Zr** zirconium 91.2	41 **Nb** niobium 92.9	42 **Mo** molybdenum 95.9	43 **Tc** technetium	44 **Ru** ruthenium 101.1	45 **Rh** rhodium 102.9	46 **Pd** palladium 106.4	47 **Ag** silver 107.9	48 **Cd** cadmium 112.4	49 **In** indium 114.8	50 **Sn** tin 118.7	51 **Sb** antimony 121.8	52 **Te** tellurium 127.6	53 **I** iodine 126.9	54 **Xe** xenon 131.3
55 **Cs** caesium 132.9	56 **Ba** barium 137.3	57–71 lanthanoids	72 **Hf** hafnium 178.5	73 **Ta** tantalum 180.9	74 **W** tungsten 183.8	75 **Re** rhenium 186.2	76 **Os** osmium 190.2	77 **Ir** iridium 192.2	78 **Pt** platinum 195.1	79 **Au** gold 197.0	80 **Hg** mercury 200.6	81 **Tl** thallium 204.4	82 **Pb** lead 207.2	83 **Bi** bismuth 209.0	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		114 **Fl** flerovium		116 **Lv** livermorium		

57 **La** lanthanum 138.9	58 **Ce** cerium 140.1	59 **Pr** praseodymium 140.9	60 **Nd** neodymium 144.2	61 **Pm** promethium 144.9	62 **Sm** samarium 150.4	63 **Eu** europium 152.0	64 **Gd** gadolinium 157.2	65 **Tb** terbium 158.9	66 **Dy** dysprosium 162.5	67 **Ho** holmium 164.9	68 **Er** erbium 167.3	69 **Tm** thulium 168.9	70 **Yb** ytterbium 173.0	71 **Lu** lutetium 175.0
89 **Ac** actinium	90 **Th** thorium 232.0	91 **Pa** protactinium	92 **U** uranium 238.1	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