Oxford Cambridge and RSA

Thursday 14 January 2021 – Morning

Level 3 Cambridge Technical in Applied Science

05847/05848/05849/05874/05879 Unit 2: Laboratory techniques

Time allowed: 2 hours
C341/2101

C341/2101

You must have:
- the Data Sheet
- a ruler (cm/mm)

You can use:
- a scientific or graphical calculator
- an HB pencil

Please write clearly in black ink.

Centre number | | | | | | Candidate number | | | | |

First name(s) ____________________

Last name ____________________

Date of birth | D | D | M | M | Y | Y | Y | Y |

INSTRUCTIONS
- Use black ink. You can use an HB pencil, but only for graphs and diagrams.
- Write your answer to each question in the space provided. If you need extra space use the lined pages at the end of this booklet. The question numbers must be clearly shown.
- Answer **all** the questions.

INFORMATION
- The total mark for this paper is **90**.
- The marks for each question are shown in brackets **[ ]**.
- The Periodic Table is on the back page.
- This document has **24** pages.

ADVICE
- Read each question carefully before you start your answer.

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

Answer **all** the questions.

1 Jane is a technician working in a laboratory.

Jane carries out an experiment to find out how much a thin wire stretches when she adds increasing loads (weights) to the wire. She wants to see if the extension of the wire is directly proportional to the load.

(a) She records the results of the experiment and notes her name and the date that the work is done.

Suggest why Jane's name and the date were recorded.

.... **[1]**

(b) **Table 1.1** shows Jane's results.

Load added / N	Length / mm	Extension of the wire
0	30	0
500	35	5
1000	40	10

Table 1.1

Jane forgets to record a key detail in one of the column headings in **Table 1.1**.

State the key detail that is missing.

.... **[1]**

(c) **(i)** Describe **two** ways the data collected can be improved to make the results of the experiment more reliable.

1 ....

2 ....
[2]

(ii) Design a table of results that would allow the data from the improved experiment to be collected.

[4]

(d) **(i)** Jane produces a risk assessment, before completing the experiment.

Describe **one** hazard that the experiment might present.

.... **[1]**

(ii) State **one** precaution that Jane should take to reduce the risk of the hazard identified in **(d)(i)**.

.... **[1]**

(e) All new employees in the laboratory must be trained in health and safety.

Suggest why it is important that all new employees are trained in health and safety.

.... **[1]**

(f) Amir is another technician working in the laboratory. He is using a pH meter to measure the pH of some acidic solutions. Before he uses the pH meter it must be calibrated.

Outline **four** of the steps involved in the calibration of a pH meter.

1 ....

....

2 ....

....

3 ....

....

4 ....

....

[4]

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2 HPLC can be used to separate the component compounds in a mixture.

Fig 2.1 shows a chromatogram of a mixture separated by HPLC.

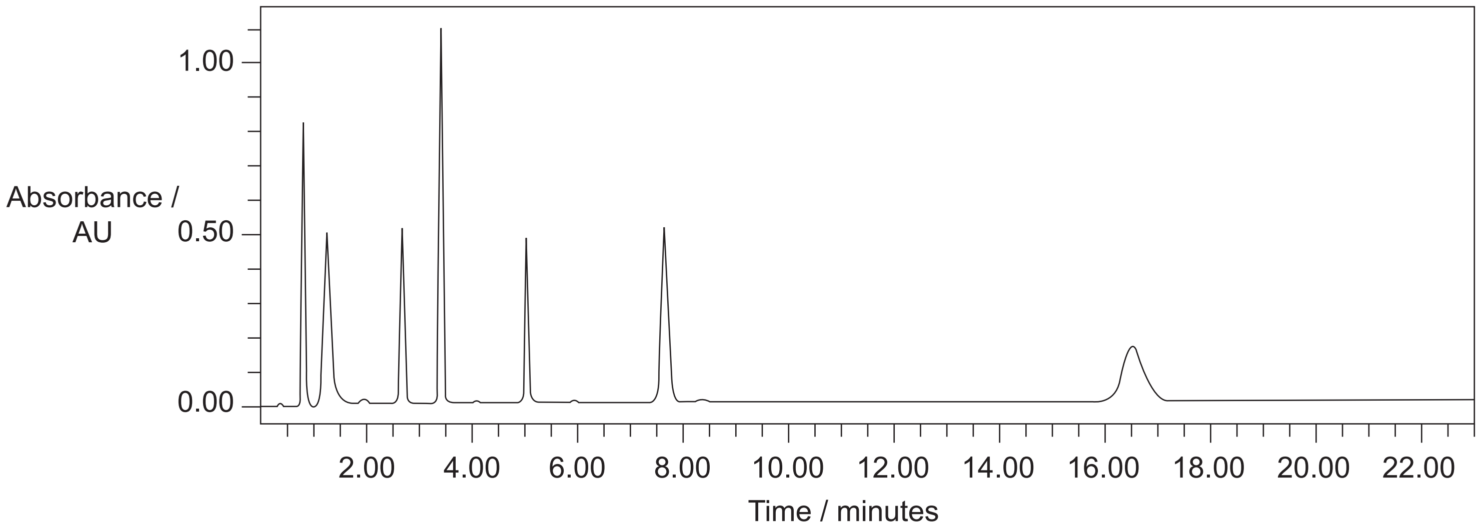

Fig 2.1

Retention times for four of the compounds are shown in **Table 2.1**.

Compound number	**Compound name**	**Retention time**
1	Paracetamol	1 minute 20 seconds
2	Theobromine	3 minutes 30 seconds
3	Theophylline	5 minutes
4	Caffeine	7 minutes 40 seconds

Table 2.1

(a) Identify four peaks in **Fig 2.1** that match the compounds listed in **Table 2.1**.

Write the compound number immediately above each correct peak in **Fig 2.1**.

[3]

(b) (i) In **Table 2.2** put a **tick** (✓) against the **three** correct advantages of linking HPLC to a mass spectrometer.

Advantage	**Tick**
Positive identification of unknown chemicals	
Technicians need less training	
Reduced cost	
Quantification of known compounds	
Reduces the time taken to separate the molecules	
Provides information on structure of compounds	

Table 2.2

[3]

(ii) Complete the sentences to explain the features of mass spectroscopy.

Use words from the list.

You can use each word once, more than once, or not at all.

electrons **gas** **gravitational** **liquid** **magnetic** **solid**

The sample eluted from an HPLC column is converted into a

....

The compounds in the sample have .... removed to form positive ions.

A .... field is then used to separate the ions according to their mass : charge ratio.

[3]

(c) Explain how thin layer chromatography (TLC) can be used to separate and identify chemicals present in samples.

Your answer should include:

- How TLC is set up.
- How TLC separates different chemicals.
- How to identify chemicals on a TLC plate by calculating R_f values.

You may include a diagram in your answer.

....

....

....

....

....

....

....

....

....

....

....

.... **[6]**

3 Titrations can be used to determine the concentration of acids or bases.

(a) 50 cm^3 of 0.1 mol dm^{-3} sodium hydroxide, NaOH, is gradually added to 25 cm^3 of 0.1 mol dm^{-3} hydrochloric acid, HCl. The pH is plotted against the volume of NaOH added.

On the axes in **Fig 3.1** sketch the shape of the titration curve and label the equivalence point.

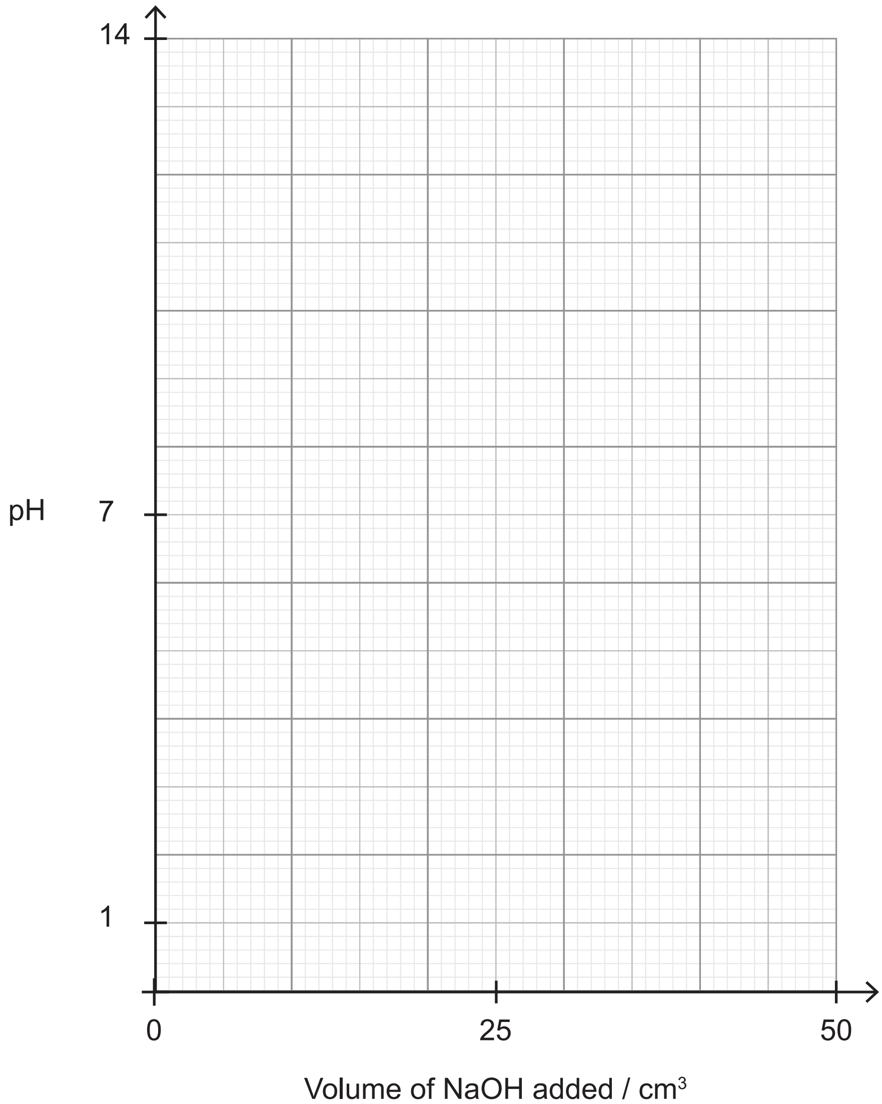

Fig 3.1

[3]

(b) **Fig 3.2a** shows the reading on a burette at the start of a titration.

Fig 3.2b shows the reading at the end-point of a titration.

Fig 3.2a

Fig 3.2b

(i) State **two** precautions that should be taken to ensure the burette reading is accurate.

1 ....

2 ....
[2]

(ii) Calculate the volume of titrant added.

Give your answer to an **appropriate number** of significant figures.

Show your working.

Volume of titrant added = ... cm^3 **[2]**

(iii) This titration was repeated. The other two titres were 20.10 cm^3 and 20.15 cm^3.

Calculate the mean volume of titrant added.

Mean volume of titrant added = ... cm^3 **[1]**

(c) Mia is a science student.

She completes a titration to determine the concentration of an aqueous solution of calcium hydroxide, $Ca(OH)_2$ (aq).

Mia finds that 19.50 cm^3 of 0.0200 mol dm^{-3} hydrochloric acid (HCl) is required to neutralise 25.00 cm^3 of the calcium hydroxide solution.

In this reaction, **two** moles of HCl are needed to neutralise **one** mole of $Ca(OH)_2$.

Mia knows that she must use the following relationship in her calculations:

$$\text{number of moles} = \frac{\text{concentration in mol dm}^{-3} \times \text{volume in cm}^3}{1000}$$

(i) Calculate the number of moles of HCl required to neutralise the $Ca(OH)_2$ solution.

Number of moles of HCl = ... mol **[1]**

(ii) Use the reacting ratio to calculate the number of moles of $Ca(OH)_2$ in 25.00 cm^3 of the calcium hydroxide solution.

Number of moles of $Ca(OH)_2$ = ... mol **[1]**

(iii) Calculate the concentration, in mol dm^{-3}, of the calcium hydroxide solution.

Concentration of $Ca(OH)_2$ = ... mol dm^{-3} **[1]**

(d) An auto-titrator is frequently used in the food industry to determine the acidity of fruit juice.

Complete the sentences about auto-titration.

Use words from the list.

You can use each word once, more than once, or not at all.

electrode	**endpoint**	**large**	**meter**
temperature	**small**	**volume**	

Auto-titrators use an .... to determine the

.... for acid base titrations.

They are programmed to add .... quantities of titrant in the

region of the .... so that the.. of

titrant needed for neutralisation can be accurately determined.

[4]

4 Kai is a technician working in a hospital laboratory.

He uses different types of microscope to view objects too small to see with the naked eye.

(a) Complete the sentences about microscopy.

Use words from the list.

You can use each word once, more than once, or not at all.

accuracy	**electron**	**graticule**	**light**	**resolution**
ruler	**size matrix**			

Living cells can be viewed using .... microscopy.

Electron microscopy has a higher .... than light microscopy.

A .... can be used to measure the size of an object when viewed by light microscopy.

[3]

(b) Kai is preparing to use a light microscope to view blood cells.

Outline **four** of the steps that Kai should take to safely focus the blood cells with the greatest magnification.

1 ....

2 ....

3 ....

4 ....

[4]

(c) **Fig 4.1** shows the image that Kai can see of a sample of blood using his light microscope.

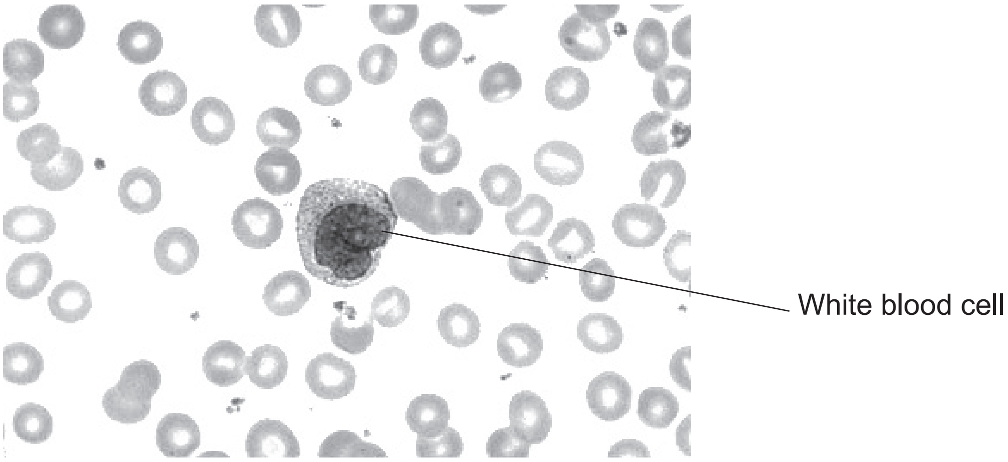

Fig 4.1

(i) In the space below make a **large** scientific line drawing of the **white blood cell** as seen by Kai in **Fig 4.1**.

[3]

(ii) Use a ruler to measure the diameter of the white blood cell in **Fig 4.1** at the widest part, to the nearest mm.

Width of white blood cell = ... mm **[1]**

(iii) The actual size of the white blood cell is 1.5×10^{-2} mm.

Calculate the magnification used to view the white blood cell in **Fig 4.1**.

Use the formula: magnification = measured size ÷ actual size

Show your working.

Magnification = × .... **[1]**

(iv) The eyepiece lens has a magnification of ×10.

Calculate the magnification of the objective lens.

Magnification = × .... **[1]**

(v) Kai viewed the white blood cell using a ×10 objective lens and a ×10 eyepiece lens.

He changes the objective lens for one with a magnification of ×40. The eyepiece lens remains the same.

Calculate the size that the white blood cell will appear when viewed using the microscope with the ×40 objective lens.

Size of white blood cell = ... mm **[2]**

5 A student is using chemical testing to identify anions.

(a) **(i)** The student is asked to consider different tests and the results expected for three anions.

For **each** of the anions listed in **Fig 5.1** draw a line to link it to the correct **test**. Then draw a line to link each test to the **positive result** expected.

Anion	**Test**	**Positive result**
Carbonate	Add a few drops of nitric acid then a few drops of silver nitrate	White precipitate produced
Bromide	Add a few drops of hydrochloric acid and then a few drops of barium chloride solution	Cream precipitate produced
Sulfate	Add a few drops of acid	Bubbles produced

Fig 5.1

[5]

(ii) One of the positive results in **Fig 5.1** produced bubbles of carbon dioxide.

Describe the test for the presence of carbon dioxide **and** the positive result.

Test ....

Positive result ....

[2]

(iii) Name **two** other anions that can be tested for by adding a few drops of nitric acid followed by silver nitrate.

1 ....

2 ....

[1]

(iv) Explain why nitric acid is added first when testing for halides.

....

....

.... **[2]**

(b) **(i)** The student finds out that flame tests and ICP-AES can both be used to identify metal ions.

Give the full name for AES.

.... **[1]**

(ii) **Table 5.1** lists some features of flame tests and ICP-AES for metal ions.

Put a tick (✓) in the correct box in each row to show if the feature is found in a **flame test** or in **ICP-AES**.

Feature	**Flame test**	**ICP-AES**
Quantitative analysis		
Cheap and easy to do		
High levels of sensitivity		
Requires high level of training		
Can be done outside of the laboratory		
Can detect multiple metals in the same sample		

Table 5.1

[4]

6 A biological research company focuses on the growth of microorganisms in a laboratory.

One of the sources for testing microorganisms is river water.

The scientists in the laboratory must make sure that the materials and equipment they use are sterile.

(a) For each item in **Table 6.1** put a tick (✓) for the most appropriate way to sterilise it.

Item	Autoclave	Spray with ethanol solution	Filter	Open flame	Dry heat
Bacterial growth medium					
Inoculating loop					
Antibiotic solutions					
Empty glassware					
Open bottle of sterile diluting water					
Inside of controlled air flow cabinets					

Table 6.1

[6]

(b) The research scientists grow microorganisms on agar plates.

They find that this is a useful way to assess the purity and number of microorganisms present in a sample.

Fig 6.1 shows a plate of yeast colonies.

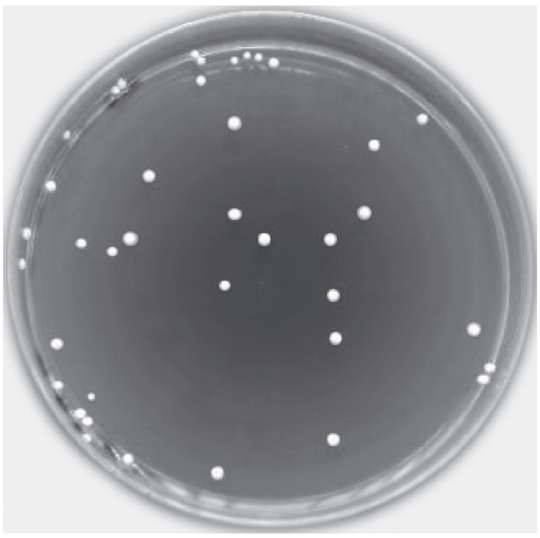

Fig 6.1

State how the plate in **Fig 6.1** shows that the yeast culture is **not** contaminated with other microorganisms.

....**[1]**

(c) The plate in **Fig 6.1** was produced by the spread plating method as follows:

- A yeast culture was grown in liquid growth medium.
- 10 cm^3 of culture was diluted with sterile water to make a final volume of 1000 cm^3.
- 0.1 cm^3 of the dilution was then spread onto the sterile plate.
- The plate was then incubated for 24 hours to allow the yeast to grow.

(i) Count the number of yeast colonies growing from the 0.1 cm^3 spread.

Number of yeast colonies on plate = ... **[1]**

(ii) Calculate the number of yeast colonies in the initial 10 cm^3 of the undiluted culture.

Number of yeast colonies in 10 cm^3 of undiluted culture = ... **[2]**

(iii) Explain why spread plating the **undiluted** yeast culture would not have been useful to work out the number of yeast colonies in the culture.

.... **[1]**

(d) The research scientists grew microorganisms from a sample of river water on an agar plate.

The plate is shown in **Fig 6.2**.

Fig 6.2

(i) Estimate how many **different** types of microorganism were growing in the river water.

Explain your answer.

....

....

.... **[2]**

(ii) State **two** reasons why it is important to maintain aseptic techniques when analysing microorganisms in river water.

1 ....

2 ....

[2]

END OF QUESTION PAPER

ADDITIONAL ANSWER SPACE

If additional answer space is required, you should use the following lined pages. The question numbers must be clearly shown in the margins – for example, 2(c) or 6(b).

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