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CHEMISTRY

9701/35

Paper 3 Advanced Practical Skills 1

October/November 2018

2 hours

Candidates answer on the Question Paper.

Additional Materials: As listed in the Confidential Instructions

READ THESE INSTRUCTIONS FIRST

Write your Centre number, candidate number and name on all the work you hand in.
Give details of the practical session and laboratory where appropriate, in the boxes provided.
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.
DO NOT WRITE IN ANY BARCODES.

Answer **all** questions.
Electronic calculators may be used.
You may lose marks if you do not show your working or if you do not use appropriate units.
Use of a Data Booklet is unnecessary.

Qualitative Analysis Notes are printed on pages 10 and 11.
A copy of the Periodic Table is printed on page 12.

At the end of the examination, fasten all your work securely together.
The number of marks is given in brackets [] at the end of each question or part question.

Session	
Laboratory	

For Examiner's Use	
1	
2	
Total	

This document consists of **12** printed pages.

Quantitative Analysis

Read through the whole method before starting any practical work. Where appropriate, prepare a table for your results in the space provided.

Show your working and appropriate significant figures in the final answer to **each** step of your calculations.

- 1 In this experiment you will determine the percentage purity of a sample of impure anhydrous sodium carbonate. You will use two different methods to measure the enthalpy change of reaction when a sample of impure anhydrous sodium carbonate reacts with excess dilute hydrochloric acid.

FA 1 is a sample of the impure anhydrous sodium carbonate.

FA 2 is 2.00 mol dm^{-3} hydrochloric acid, HCl .

FA 3 is a second sample of the impure anhydrous sodium carbonate used in **FA 1**.

(a) Method 1

- Weigh the container with **FA 1**. Record this mass.

mass of container with **FA 1** = g

- Support one of the plastic cups in the 250 cm^3 beaker.
- Use the measuring cylinder to place 25 cm^3 of **FA 2** into the cup.
- Measure the temperature of the **FA 2** in the cup. Tilt the cup if necessary so that the bulb of the thermometer is fully covered. Record this temperature at time $t = 0$.
- Start the stopclock and leave it running for the whole experiment.
- Measure and record the temperature of **FA 2** in the cup every half minute for 2 minutes.
- At $t = 2\frac{1}{2}$ minutes tip all the **FA 1** into the cup. Stir the contents of the cup.
- Measure and record the temperature of the contents of the cup at $t = 3$ minutes and then every half minute up to $t = 9$ minutes.
- Weigh the container with any residual **FA 1**. Record this mass.

I	
II	
III	
IV	
V	

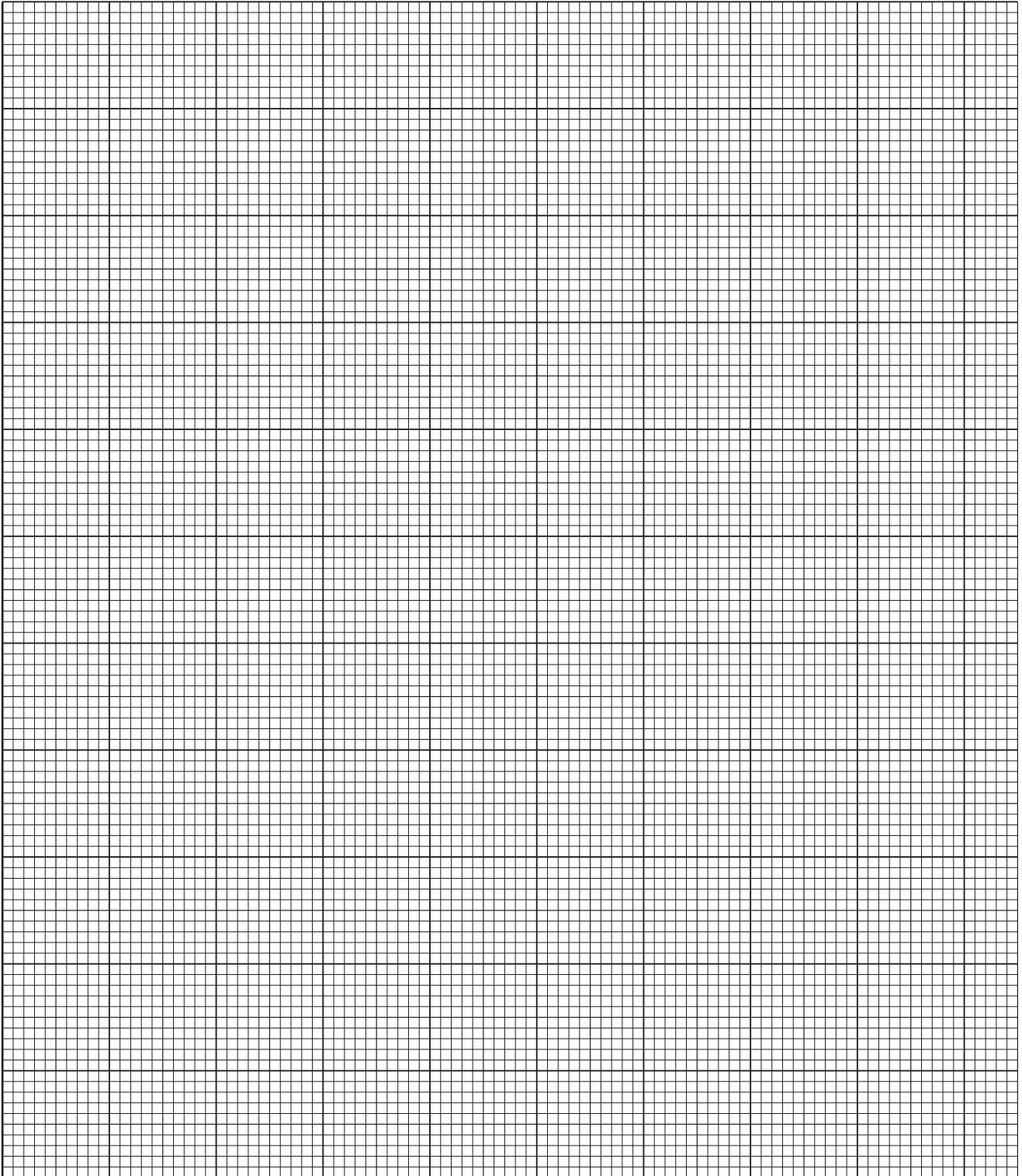
mass of container with residual **FA 1** = g
[5]

- (b) (i) On the grid on page 3, plot a graph of temperature (y -axis) against time (x -axis). You should choose a scale that allows you to plot 2°C above the maximum temperature reached.

I	
II	
III	
IV	

On your graph, draw two straight lines of best fit. One line is for the temperature before adding **FA 1** and the other line for the cooling of the solution once reaction is complete.

Extrapolate these two lines to $t = 2\frac{1}{2}$ minutes. [4]



(ii) From your graph, find the theoretical temperature rise at $t = 2\frac{1}{2}$ minutes.

theoretical temperature rise = °C [1]

(c) (i) Calculate the energy released in the reaction.

(Assume 4.2 J of heat energy changes the temperature of 1.0 cm³ of solution by 1.0 °C.)

energy released = J [1]

(ii) The equation for the reaction between anhydrous sodium carbonate and hydrochloric acid is shown.



The literature value for the enthalpy change of this reaction is $-27.0 \text{ kJ mol}^{-1}$.

Use this figure, and the value that you found in (i), to find the mass of anhydrous sodium carbonate you used in (a). You should assume that no energy was lost to the surroundings in your experiment.

mass Na_2CO_3 = g [2]

(iii) Calculate the percentage of anhydrous sodium carbonate present in **FA 1**.

percentage Na_2CO_3 in **FA 1** = % [1]

(d) In your calculation in (c), what assumption have you made about the impurity present in **FA 1**?

.....
 [1]

(e) Method 2

- Weigh a clean, dry plastic cup and record the mass.
- Add between 1.70g and 1.90g of **FA 3** to the plastic cup and record the mass.
- Support the plastic cup in the 250 cm³ beaker.
- Pour 25 cm³ of **FA 2** into the measuring cylinder.
- Measure and record the initial temperature of **FA 2** in the measuring cylinder.
- Pour the 25 cm³ of **FA 2** into the plastic cup.
- Stir the contents of the cup and record the maximum temperature. Tilt the cup if necessary so that the bulb of the thermometer is fully covered.
- Calculate and record the mass of **FA 3** used and the change in temperature.

[2]

- (f)** Use the temperature rise in **(e)**, and the fact that the enthalpy change for the reaction between anhydrous sodium carbonate and hydrochloric acid is $-27.0 \text{ kJ mol}^{-1}$, to calculate the percentage of anhydrous sodium carbonate in **FA 3**.

percentage Na₂CO₃ in **FA 3** = % [2]

- (g) **FA 1** and **FA 3** are both samples of the same impure anhydrous sodium carbonate and so the percentage of anhydrous sodium carbonate found using **Method 1** and **Method 2** should be the same. In practice the percentages are sometimes different from each other.

In both methods, percentage errors occur due to measuring the mass of solid and the temperature rise.

Ignoring these errors, which method is more accurate?

Tick the correct box and explain your answer.

Method 1 more accurate

Method 2 more accurate

Method 1 and Method 2 equally accurate

.....

.....

.....

[1]

- (h) A student decided to confirm by experiment the literature value for the enthalpy change of the reaction between anhydrous sodium carbonate and hydrochloric acid. By mistake the student weighed a sample of hydrated sodium carbonate, $\text{Na}_2\text{CO}_3 \cdot 10\text{H}_2\text{O}$, instead of anhydrous sodium carbonate, Na_2CO_3 .

State what effect this would have on the calculated value of the enthalpy change for the reaction. Explain your answer.

.....

.....

.....

..... [2]

- (i) A student used 3.00g of anhydrous sodium carbonate that was 80.0% pure by mass.

Calculate the minimum volume of 2.00 mol dm^{-3} hydrochloric acid that would be needed to react completely with this sample of impure anhydrous sodium carbonate.

volume of $\text{HCl} = \dots\dots\dots \text{ cm}^3$ [3]

[Total: 25]

Qualitative Analysis

Where reagents are selected for use in a test, the **full name** or **correct formula** of the element or compound must be given.

At each stage of any test you are to record details of the following:

- colour changes seen;
- the formation of any precipitate and its solubility in an excess of the reagent added;
- the formation of any gas and its identification by a suitable test.

You should indicate clearly at what stage in a test a change occurs.

If any solution is warmed, a **boiling tube** must be used.

Rinse and reuse test-tubes and boiling tubes where possible.

No additional tests for ions present should be attempted.

- 2 (a) (i) **FA 4** is a sodium compound that was the impurity in the **FA 1** and **FA 3** that you used in **Question 1**. The anion in **FA 4** is one of those listed in the Qualitative Analysis Notes.

Carry out appropriate tests to allow you to positively identify the anion in **FA 4**.

For the test that gives a positive result, record the test and the results of it.
State the name of the anion in **FA 4**.

anion in **FA 4** =

[2]

- (ii) Write the ionic equation for the reaction that you have used to identify the anion in **FA 4**.
Include state symbols.

..... [1]

- (b) **FA 5** is a mixture that contains two cations and three anions from those listed in the Qualitative Analysis Notes.

A sample of **FA 5** was added to water and the water stirred. The mixture produced was filtered to give a solid residue, **FA 6**, and a filtrate, **FA 7**.

- (i) Carry out the following tests on **FA 6** and record your observations.

<i>test</i>	<i>observations</i>
To a small spatula measure of FA 6 in a test-tube add dilute hydrochloric acid, then	
add aqueous ammonia.	
Place a small spatula measure of FA 6 in a hard-glass test-tube and heat gently.	

[4]

- (ii) Carry out the following tests on **FA 7** and record your observations.

<i>test</i>	<i>observations</i>
To a 1 cm depth of FA 7 in a test-tube add aqueous sodium hydroxide.	
To a 1 cm depth of FA 7 in a test-tube add aqueous ammonia.	
To a 1 cm depth of FA 7 in a test-tube add a few drops of aqueous silver nitrate.	
To a 1 cm depth of FA 7 in a test-tube add a few drops of aqueous barium nitrate or aqueous barium chloride, then	
add dilute nitric acid.	
To a 0.5 cm depth of FA 7 in a boiling tube add a 2 cm depth of aqueous sodium hydroxide and warm, then	
add a small piece of aluminium foil.	

[5]

(iii) From your observations, identify the two cations present in **FA 5**.

cations and [1]

(iv) From your observations, identify two anions present in **FA 5**.

..... [1]

(v) From your observations, identify two anions that could be present in **FA 5**.

..... [1]

[Total: 15]

Qualitative Analysis Notes

1 Reactions of aqueous cations

ion	reaction with	
	NaOH(aq)	NH ₃ (aq)
aluminium, Al ³⁺ (aq)	white ppt. soluble in excess	white ppt. insoluble in excess
ammonium, NH ₄ ⁺ (aq)	no ppt. ammonia produced on heating	–
barium, Ba ²⁺ (aq)	faint white ppt. is nearly always observed unless reagents are pure	no ppt.
calcium, Ca ²⁺ (aq)	white ppt. with high [Ca ²⁺ (aq)]	no ppt.
chromium(III), Cr ³⁺ (aq)	grey-green ppt. soluble in excess	grey-green ppt. insoluble in excess
copper(II), Cu ²⁺ (aq)	pale blue ppt. insoluble in excess	blue ppt. soluble in excess giving dark blue solution
iron(II), Fe ²⁺ (aq)	green ppt. turning brown on contact with air insoluble in excess	green ppt. turning brown on contact with air insoluble in excess
iron(III), Fe ³⁺ (aq)	red-brown ppt. insoluble in excess	red-brown ppt. insoluble in excess
magnesium, Mg ²⁺ (aq)	white ppt. insoluble in excess	white ppt. insoluble in excess
manganese(II), Mn ²⁺ (aq)	off-white ppt. rapidly turning brown on contact with air insoluble in excess	off-white ppt. rapidly turning brown on contact with air insoluble in excess
zinc, Zn ²⁺ (aq)	white ppt. soluble in excess	white ppt. soluble in excess

2 Reactions of anions

<i>ion</i>	<i>reaction</i>
carbonate, CO_3^{2-}	CO_2 liberated by dilute acids
chloride, $\text{Cl}^-(\text{aq})$	gives white ppt. with $\text{Ag}^+(\text{aq})$ (soluble in $\text{NH}_3(\text{aq})$)
bromide, $\text{Br}^-(\text{aq})$	gives cream ppt. with $\text{Ag}^+(\text{aq})$ (partially soluble in $\text{NH}_3(\text{aq})$)
iodide, $\text{I}^-(\text{aq})$	gives yellow ppt. with $\text{Ag}^+(\text{aq})$ (insoluble in $\text{NH}_3(\text{aq})$)
nitrate, $\text{NO}_3^-(\text{aq})$	NH_3 liberated on heating with $\text{OH}^-(\text{aq})$ and Al foil
nitrite, $\text{NO}_2^-(\text{aq})$	NH_3 liberated on heating with $\text{OH}^-(\text{aq})$ and Al foil
sulfate, $\text{SO}_4^{2-}(\text{aq})$	gives white ppt. with $\text{Ba}^{2+}(\text{aq})$ (insoluble in excess dilute strong acids)
sulfite, $\text{SO}_3^{2-}(\text{aq})$	gives white ppt. with $\text{Ba}^{2+}(\text{aq})$ (soluble in excess dilute strong acids)

3 Tests for gases

<i>gas</i>	<i>test and test result</i>
ammonia, NH_3	turns damp red litmus paper blue
carbon dioxide, CO_2	gives a white ppt. with limewater (ppt. dissolves with excess CO_2)
chlorine, Cl_2	bleaches damp litmus paper
hydrogen, H_2	'pops' with a lighted splint
oxygen, O_2	relights a glowing splint

The Periodic Table of Elements

Group																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																											
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3 Li lithium 6.9	4 Be beryllium 9.0	11 Na sodium 23.0	12 Mg magnesium 24.3	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 Fr francium —	58 Ra radium —	59 Pr praseodymium 140.9	60 Nd neodymium 144.4	61 Pm promethium —	62 Sm samarium 150.4	63 Eu europium 152.0	64 Gd gadolinium 157.3	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 173.1	71 Lu lutetium 175.0	72 La lanthanum 138.9	73 Ce cerium 140.1	74 Pr praseodymium 140.9	75 Nd neodymium 144.4	76 Pm promethium —	77 Sm samarium 150.4	78 Eu europium 152.0	79 Gd gadolinium 157.3	80 Tb terbium 158.9	81 Dy dysprosium 162.5	82 Ho holmium 164.9	83 Er erbium 167.3	84 Tm thulium 168.9	85 Yb ytterbium 173.1	86 Lu lutetium 175.0	87 Ac actinium —	88 Th thorium 232.0	89 Pa protactinium 231.0	90 U uranium 238.0	91 Np neptunium —	92 Pu plutonium —	93 Am americium —	94 Cm curium —	95 Bk berkelium —	96 Cf californium —	97 Es einsteinium —	98 Fm fermium —	99 Md mendelevium —	100 No nobelium —	101 Lr lawrencium —	102 Rn radon —	103 Fr francium —	104 Ra radium —	105 Ac actinium —	106 Th thorium —	107 Pa protactinium —	108 U uranium —	109 Np neptunium —	110 Pu plutonium —	111 Am americium —	112 Cm curium —	113 Bk berkelium —	114 Cf californium —	115 Es einsteinium —	116 Fm fermium —	117 Md mendelevium —	118 No nobelium —	119 Lr lawrencium —	120 Rn radon —	121 Fr francium —	122 Ra radium —	123 Ac actinium —	124 Th thorium —	125 Pa protactinium —	126 U uranium —	127 Np neptunium —	128 Pu plutonium —	129 Am americium —	130 Cm curium —	131 Bk berkelium —	132 Cf californium —	133 Es einsteinium —	134 Fm fermium —	135 Md mendelevium —	136 No nobelium —	137 Lr lawrencium —	138 Rn radon —	139 Fr francium —	140 Ra radium —	141 Ac actinium —	142 Th thorium —	143 Pa protactinium —	144 U uranium —	145 Np neptunium —	146 Pu plutonium —	147 Am americium —	148 Cm curium —	149 Bk berkelium —	150 Cf californium —	151 Es einsteinium —	152 Fm fermium —	153 Md mendelevium —	154 No nobelium —	155 Lr lawrencium —	156 Rn radon —	157 Fr francium —	158 Ra radium —	159 Ac actinium —	160 Th thorium —	161 Pa protactinium —	162 U uranium —	163 Np neptunium —	164 Pu plutonium —	165 Am americium —	166 Cm curium —	167 Bk berkelium —	168 Cf californium —	169 Es einsteinium —	170 Fm fermium —	171 Md mendelevium —	172 No nobelium —	173 Lr lawrencium —	174 Rn radon —	175 Fr francium —	176 Ra radium —	177 Ac actinium —	178 Th thorium —	179 Pa protactinium —	180 U uranium —	181 Np neptunium —	182 Pu plutonium —	183 Am americium —	184 Cm curium —	185 Bk berkelium —	186 Cf californium —	187 Es einsteinium —	188 Fm fermium —	189 Md mendelevium —	190 No nobelium —	191 Lr lawrencium —	192 Rn radon —	193 Fr francium —	194 Ra radium —	195 Ac actinium —	196 Th thorium —	197 Pa protactinium —	198 U uranium —	199 Np neptunium —	200 Pu plutonium —	201 Am americium —	202 Cm curium —	203 Bk berkelium —	204 Cf californium —	205 Es einsteinium —	206 Fm fermium —	207 Md mendelevium —	208 No nobelium —	209 Lr lawrencium —	210 Rn radon —	211 Fr francium —	212 Ra radium —	213 Ac actinium —	214 Th thorium —	215 Pa protactinium —	216 U uranium —	217 Np neptunium —	218 Pu plutonium —	219 Am americium —	220 Cm curium —	221 Bk berkelium —	222 Cf californium —	223 Es einsteinium —	224 Fm fermium —	225 Md mendelevium —	226 No nobelium —	227 Lr lawrencium —	228 Rn radon —	229 Fr francium —	230 Ra radium —	231 Ac actinium —	232 Th thorium —	233 Pa protactinium —	234 U uranium —	235 Np neptunium —	236 Pu plutonium —	237 Am americium —	238 Cm curium —	239 Bk berkelium —	240 Cf californium —	241 Es einsteinium —	242 Fm fermium —	243 Md mendelevium —	244 No nobelium —	245 Lr lawrencium —	246 Rn radon —	247 Fr francium —	248 Ra radium —	249 Ac actinium —	250 Th thorium —	251 Pa protactinium —	252 U uranium —	253 Np neptunium —	254 Pu plutonium —	255 Am americium —	256 Cm curium —	257 Bk berkelium —	258 Cf californium —	259 Es einsteinium —	260 Fm fermium —	261 Md mendelevium —	262 No nobelium —	263 Lr lawrencium —	264 Rn radon —	265 Fr francium —	266 Ra radium —	267 Ac actinium —	268 Th thorium —	269 Pa protactinium —	270 U uranium —	271 Np neptunium —	272 Pu plutonium —	273 Am americium —	274 Cm curium —	275 Bk berkelium —	276 Cf californium —	277 Es einsteinium —	278 Fm fermium —	279 Md mendelevium —	280 No nobelium —	281 Lr lawrencium —	282 Rn radon —	283 Fr francium —	284 Ra radium —	285 Ac actinium —	286 Th thorium —	287 Pa protactinium —	288 U uranium —	289 Np neptunium —	290 Pu plutonium —	291 Am americium —	292 Cm curium —	293 Bk berkelium —	294 Cf californium —	295 Es einsteinium —	296 Fm fermium —	297 Md mendelevium —	298 No nobelium —	299 Lr lawrencium —	300 Rn radon —	301 Fr francium —	302 Ra radium —	303 Ac actinium —	304 Th thorium —	305 Pa protactinium —	306 U uranium —	307 Np neptunium —	308 Pu plutonium —	309 Am americium —	310 Cm curium —	311 Bk berkelium —	312 Cf californium —	313 Es einsteinium —	314 Fm fermium —	315 Md mendelevium —	316 No nobelium —	317 Lr lawrencium —	318 Rn radon —	319 Fr francium —	320 Ra radium —	321 Ac actinium —	322 Th thorium —	323 Pa protactinium —	324 U uranium —	325 Np neptunium —	326 Pu plutonium —	327 Am americium —	328 Cm curium —	329 Bk berkelium —	330 Cf californium —	331 Es einsteinium —	332 Fm fermium —	333 Md mendelevium —	334 No nobelium —	335 Lr lawrencium —	336 Rn radon —	337 Fr francium —	338 Ra radium —	339 Ac actinium —	340 Th thorium —	341 Pa protactinium —	342 U uranium —	343 Np neptunium —	344 Pu plutonium —	345 Am americium —	346 Cm curium —	347 Bk berkelium —	348 Cf californium —	349 Es einsteinium —	350 Fm fermium —	351 Md mendelevium —	352 No nobelium —	353 Lr lawrencium —	354 Rn radon —	355 Fr francium —	356 Ra radium —	357 Ac actinium —	358 Th thorium —	359 Pa protactinium —	360 U uranium —	361 Np neptunium —	362 Pu plutonium —	363 Am americium —	364 Cm curium —	365 Bk berkelium —	366 Cf californium —	367 Es einsteinium —	368 Fm fermium —	369 Md mendelevium —	370 No nobelium —	371 Lr lawrencium —	372 Rn radon —	373 Fr francium —	374 Ra radium —	375 Ac actinium —	376 Th thorium —	377 Pa protactinium —	378 U uranium —	379 Np neptunium —	380 Pu plutonium —	381 Am americium —	382 Cm curium —	383 Bk berkelium —	384 Cf californium —	385 Es einsteinium —	386 Fm fermium —	387 Md mendelevium —	388 No nobelium —	389 Lr lawrencium —	390 Rn radon —	391 Fr francium —	392 Ra radium —	393 Ac actinium —	394 Th thorium —	395 Pa protactinium —	396 U uranium —	397 Np neptunium —	398 Pu plutonium —	399 Am americium —	400 Cm curium —	401 Bk berkelium —	402 Cf californium —	403 Es einsteinium —	404 Fm fermium —	405 Md mendelevium —	406 No nobelium —	407 Lr lawrencium —	408 Rn radon —	409 Fr francium —	410 Ra radium —	411 Ac actinium —	412 Th thorium —	413 Pa protactinium —	414 U uranium —	415 Np neptunium —	416 Pu plutonium —	417 Am americium —	418 Cm curium —	419 Bk berkelium —	420 Cf californium —	421 Es einsteinium —	422 Fm fermium —	423 Md mendelevium —	424 No nobelium —	425 Lr lawrencium —	426 Rn radon —	427 Fr francium —	428 Ra radium —	429 Ac actinium —	430 Th thorium —	431 Pa protactinium —	432 U uranium —	433 Np neptunium —	434 Pu plutonium —	435 Am americium —	436 Cm curium —	437 Bk berkelium —	438 Cf californium —	439 Es einsteinium —	440 Fm fermium —	441 Md mendelevium —	442 No nobelium —	443 Lr lawrencium —	444 Rn radon —	445 Fr francium —	446 Ra radium —	447 Ac actinium —	448 Th thorium —	449 Pa protactinium —	450 U uranium —	451 Np neptunium —	452 Pu plutonium —	453 Am americium —	454 Cm curium —	455 Bk berkelium —	456 Cf californium —	457 Es einsteinium —	458 Fm fermium —	459 Md mendelevium —	460 No nobelium —	461 Lr lawrencium —	462 Rn radon —	463 Fr francium —	464 Ra radium —	465 Ac actinium —	466 Th thorium —	467 Pa protactinium —	468 U uranium —	469 Np neptunium —	470 Pu plutonium —	471 Am americium —	472 Cm curium —	473 Bk berkelium —	474 Cf californium —	475 Es einsteinium —	476 Fm fermium —	477 Md mendelevium —	478 No nobelium —	479 Lr lawrencium —	480 Rn radon —	481 Fr francium —	482 Ra radium —	483 Ac actinium —	484 Th thorium —	485 Pa protactinium —	486 U uranium —	487 Np neptunium —	488 Pu plutonium —	489 Am americium —	490 Cm curium —	491 Bk berkelium —	492 Cf californium —	493 Es einsteinium —	494 Fm fermium —	495 Md mendelevium —	496 No nobelium —	497 Lr lawrencium —	498 Rn radon —	499 Fr francium —	500 Ra radium —	501 Ac actinium —	502 Th thorium —	503 Pa protactinium —	504 U uranium —	505 Np neptunium —	506 Pu plutonium —	507 Am americium —	508 Cm curium —	509 Bk berkelium —	510 Cf californium —	511 Es einsteinium —	512 Fm fermium —	513 Md mendelevium —	514 No nobelium —	515 Lr lawrencium —	516 Rn radon —	517 Fr francium —	518 Ra radium —	519 Ac actinium —	520 Th thorium —	521 Pa protactinium —	522 U uranium —	523 Np neptunium —	524 Pu plutonium —	525 Am americium —	526 Cm curium —	527 Bk berkelium —	528 Cf californium —	529 Es einsteinium —	530 Fm fermium —	531 Md mendelevium —	532 No nobelium —	533 Lr lawrencium —	534 Rn radon —	535 Fr francium —	536 Ra radium —	537 Ac actinium —	538 Th thorium —	539 Pa protactinium —	540 U uranium —	541 Np neptunium —	542 Pu plutonium —	543 Am americium —	544 Cm curium —	545 Bk berkelium —	546 Cf californium —	547 Es einsteinium —	548 Fm fermium —	549 Md mendelevium —	550 No nobelium —	551 Lr lawrencium —	552 Rn radon —	553 Fr francium —	554 Ra radium —	555 Ac actinium —	556 Th thorium —	557 Pa protactinium —	558 U uranium —	559 Np neptunium —	560 Pu plutonium —	561 Am americium —	562 Cm curium —	563 Bk berkelium —	564 Cf californium —	565 Es einsteinium —	566 Fm fermium —	567 Md mendelevium —	568 No nobelium —	569 Lr lawrencium —	570 Rn radon —	571 Fr francium —	572 Ra radium —	573 Ac actinium —	574 Th thorium —	575 Pa protactinium —	576 U uranium —	577 Np neptunium —	578 Pu plutonium —	579 Am americium —	580 Cm curium —	581 Bk berkelium —	582 Cf californium —	583 Es einsteinium —	584 Fm fermium —	585 Md mendelevium —	586 No nobelium —	587 Lr lawrencium —	588 Rn radon —	589 Fr francium —	590 Ra radium —	591 Ac actinium —	592 Th thorium —	593 Pa protactinium —	594 U uranium —	595 Np neptunium —	596 Pu plutonium —	597 Am americium —	598 Cm curium —	599 Bk berkelium —	600 Cf californium —	601 Es einsteinium —	602 Fm fermium —</