

40 Chromatography is used to separate and analyse mixtures of soluble substances.

The first steps of the process are listed.

- apply sample to baseline
- develop chromatogram in solvent

What is the next step in the process to detect soluble **colourless** substances?

- A** calculate the R_f values
- B** compare the results with known substances
- C** count the number of spots
- D** use a suitable locating agent

The Periodic Table of Elements

Group																		
I	II	Key										III	IV	V	VI	VII	VIII	
		atomic number atomic symbol name relative atomic mass										1 H hydrogen 1						
3 Li lithium 7	4 Be beryllium 9											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											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 dm³ at room temperature and pressure (r.t.p.).

40 A colourless mixture is separated by paper chromatography.

The steps below describe the method. These steps are **not** in the correct order.

- 1 Remove the chromatography paper from the solvent when the solvent front is near the top of the paper.
- 2 Place the chromatography paper in the solvent.
- 3 Spray the chromatography paper with a locating agent.
- 4 Place a spot of the mixture on the pencil line.
- 5 Draw a pencil line at the bottom of the chromatography paper.
- 6 Draw a pencil line to mark the position of the solvent front.

What is the correct order for these steps?

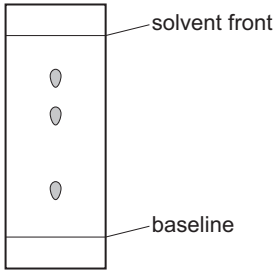
- A 3 → 5 → 6 → 4 → 2 → 1
- B 5 → 4 → 3 → 2 → 1 → 6
- C 3 → 5 → 4 → 1 → 2 → 6
- D 5 → 4 → 2 → 1 → 6 → 3

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ununseptium —	146 Uuo ununoctium —	147 Uus ununseptium —	148 Uuo ununoctium —	149 Uus ununseptium —	150 Uuo ununoctium —	151 Uus ununseptium —	152 Uuo ununoctium —	153 Uus ununseptium —	154 Uuo ununoctium —	155 Uus ununseptium —	156 Uuo ununoctium —	157 Uus ununseptium —	158 Uuo ununoctium —	159 Uus ununseptium —	160 Uuo ununoctium —	161 Pm promethium —	162 Sm samarium 150	163 Eu europium 152	164 Gd gadolinium 157	165 Tb terbium 159	166 Dy dysprosium 163	167 Ho holmium 165	168 Er erbium 167	169 Tm thulium 169	170 Yb ytterbium 173	171 Lu lutetium 175	172 Hf hafnium 178	173 Ta tantalum 181	174 W tungsten 184	175 Re rhenium 186	176 Os osmium 190	177 Ir iridium 192	178 Pt platinum 195	179 Au gold 197	180 Hg mercury 201	181 Tl thallium 204	182 Pb lead 207	183 Bi bismuth 209	184 Po polonium —	185 At astatine —	186 Rn radon —	187 Fr francium —	188 Ra radium —	189–190 actinoids	191 Ac actinium —	192 Th thorium 232	193 Pa protactinium 231	194 U uranium 238	195 Np neptunium —	196 Pu plutonium —	197 Am americium —	198 Cm curium —	199 Bk berkelium —	200 Cf californium —	201 Es einsteinium —	202 Fm fermium —	203 Md mendelevium —	204 No nobelium —	205 Lr lawrencium —	206 Uub ununbium —	207 Uut ununtrium —	208 Uuq ununquadium —	209 Uub ununbium —	210 Uut ununtrium —	211 Uuq ununquadium —	212 Uub ununbium —	213 Uut ununtrium —	214 Uuq ununquadium —	215 Uub ununbium —	216 Uut ununtrium —	217 Uuq ununquadium —	218 Uub ununbium —	219 Uut ununtrium —	220 Uuq ununquadium —	221 Uub ununbium —	222 Uut ununtrium —	223 Uuq ununquadium —	224 Uub ununbium —	225 Uut ununtrium —	226 Uuq ununquadium —	227 Uub ununbium —	228 Uut ununtrium —	229 Uuq ununquadium —	230 Uub ununbium —	231 Uut ununtrium —	232 Uuq ununquadium —	233 Uub ununbium —	234 Uut ununtrium —	235 Uuq ununquadium —	236 Uub ununbium —	237 Uut ununtrium —	238 Uuq ununquadium —	239 Uub ununbium —	240 Uut ununtrium —	241 Uuq ununquadium —	242 Uub ununbium —	243 Uut ununtrium —	244 Uuq ununquadium —	245 Uub ununbium —	246 Uut ununtrium —	247 Uuq ununquadium —	248 Uub ununbium —	249 Uut ununtrium —	250 Uuq ununquadium —	251 Uub ununbium —	252 Uut ununtrium —	253 Uuq ununquadium —	254 Uub ununbium —	255 Uut ununtrium —	256 Uuq ununquadium —	257 Uub ununbium —	258 Uut ununtrium —	259 Uuq ununquadium —	260 Uub ununbium —	261 Uut ununtrium —	262 Uuq ununquadium —	263 Uub ununbium —	264 Uut ununtrium —	265 Uuq ununquadium —	266 Uub ununbium —	267 Uut ununtrium —	268 Uuq ununquadium —	269 Uub ununbium —	270 Uut ununtrium —	271 Uuq ununquadium —	272 Uub ununbium —	273 Uut ununtrium —	274 Uuq ununquadium —	275 Uub ununbium —	276 Uut ununtrium —	277 Uuq ununquadium —	278 Uub ununbium —	279 Uut ununtrium —	280 Uuq ununquadium —	281 Uub ununbium —	282 Uut ununtrium —	283 Uuq ununquadium —	284 Uub ununbium —	285 Uut ununtrium —	286 Uuq ununquadium —	287 Uub ununbium —	288 Uut ununtrium —	289 Uuq ununquadium —	290 Uub ununbium —	291 Uut ununtrium —	292 Uuq ununquadium —	293 Uub ununbium —	294 Uut ununtrium —	295 Uuq ununquadium —	296 Uub ununbium —	297 Uut ununtrium —	298 Uuq ununquadium —	299 Uub ununbium —	300 Uut ununtrium —	301 Uuq ununquadium —	302 Uub ununbium —	303 Uut ununtrium —	304 Uuq ununquadium —	305 Uub ununbium —	306 Uut ununtrium —	307 Uuq ununquadium —	308 Uub ununbium —	309 Uut ununtrium —	310 Uuq ununquadium —	311 Uub ununbium —	312 Uut ununtrium —	313 Uuq ununquadium —	314 Uub ununbium —	315 Uut ununtrium —	316 Uuq ununquadium —	317 Uub ununbium —	318 Uut ununtrium —	319 Uuq ununquadium —	320 Uub ununbium —	321 Uut ununtrium —	322 Uuq ununquadium —	323 Uub ununbium —	324 Uut ununtrium —	325 Uuq ununquadium —	326 Uub ununbium —	327 Uut ununtrium —	328 Uuq ununquadium —	329 Uub ununbium —	330 Uut ununtrium —	331 Uuq ununquadium —	332 Uub ununbium —	333 Uut ununtrium —	334 Uuq ununquadium —	335 Uub ununbium —	336 Uut ununtrium —	337 Uuq ununquadium —	338 Uub ununbium —	339 Uut ununtrium —	340 Uuq ununquadium —	341 Uub ununbium —	342 Uut ununtrium —	343 Uuq ununquadium —	344 Uub ununbium —	345 Uut ununtrium —	346 Uuq ununquadium —	347 Uub ununbium —	348 Uut ununtrium —	349 Uuq ununquadium —	350 Uub ununbium —	351 Uut ununtrium —	352 Uuq ununquadium —	353 Uub ununbium —	354 Uut ununtrium —	355 Uuq ununquadium —	356 Uub ununbium —	357 Uut ununtrium —	358 Uuq ununquadium —	359 Uub ununbium —	360 Uut ununtrium —	361 Uuq ununquadium —	362 Uub ununbium —	363 Uut ununtrium —	364 Uuq ununquadium —	365 Uub ununbium —	366 Uut ununtrium —	367 Uuq ununquadium —	368 Uub ununbium —	369 Uut ununtrium —	370 Uuq ununquadium —	371 Uub ununbium —	372 Uut ununtrium —	373 Uuq ununquadium —	374 Uub ununbium —	375 Uut ununtrium —	376 Uuq ununquadium —	377 Uub ununbium —	378 Uut ununtrium —	379 Uuq ununquadium —	380 Uub ununbium —	381 Uut ununtrium —	382 Uuq ununquadium —	383 Uub ununbium —	384 Uut ununtrium —	385 Uuq ununquadium —	386 Uub ununbium —	387 Uut ununtrium —	388 Uuq ununquadium —	389 Uub ununbium —	390 Uut ununtrium —	391 Uuq ununquadium —	392 Uub ununbium —	393 Uut ununtrium —	394 Uuq ununquadium —	395 Uub ununbium —	396 Uut ununtrium —	397 Uuq ununquadium —	398 Uub ununbium —	399 Uut ununtrium —	400 Uuq ununquadium —	401 Uub ununbium —	402 Uut ununtrium —	403 Uuq ununquadium —	404 Uub ununbium —	405 Uut ununtrium —	406 Uuq ununquadium —	407 Uub ununbium —	408 Uut ununtrium —	409 Uuq ununquadium —	410 Uub ununbium —	411 Uut ununtrium —	412 Uuq ununquadium —	413 Uub ununbium —	414 Uut ununtrium —	415 Uuq ununquadium —	416 Uub ununbium —	417 Uut ununtrium —	418 Uuq ununquadium —	419 Uub ununbium —	420 Uut ununtrium —	421 Uuq ununquadium —	422 Uub ununbium —	423 Uut ununtrium —	424 Uuq ununquadium —	425 Uub ununbium —	426 Uut ununtrium —	427 Uuq ununquadium —	428 Uub ununbium —	429 Uut ununtrium —	430 Uuq ununquadium —	431 Uub ununbium —	432 Uut ununtrium —	433 Uuq ununquadium —	434 Uub ununbium —	435 Uut ununtrium —	436 Uuq ununquadium —	437 Uub ununbium —	438 Uut ununtrium —	439 Uuq ununquadium —	440 Uub ununbium —	441 Uut ununtrium —	442 Uuq 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ununbium —	492 Uut ununtrium —	493 Uuq ununquadium —	494 Uub ununbium —	495 Uut ununtrium —	496 Uuq ununquadium —	497 Uub ununbium —	498 Uut ununtrium —	499 Uuq ununquadium —	500 Uub ununbium —	501 Uut ununtrium —	502 Uuq ununquadium —	503 Uub ununbium —	504 Uut ununtrium —	505 Uuq ununquadium —	506 Uub ununbium —	507 Uut ununtrium —	508 Uuq ununquadium —	509 Uub ununbium —	510 Uut ununtrium —	511 Uuq ununquadium —	512 Uub ununbium —	513 Uut ununtrium —	514 Uuq ununquadium —	515 Uub ununbium —	516 Uut ununtrium —	517 Uuq ununquadium —	518 Uub ununbium —	519 Uut ununtrium —	520 Uuq ununquadium —	521 Uub ununbium —	522 Uut ununtrium —	523 Uuq ununquadium —	524 Uub ununbium —	525 Uut ununtrium —	526 Uuq ununquadium —	527 Uub ununbium —	528 Uut ununtrium —	529 Uuq ununquadium —	530 Uub ununbium —	531 Uut ununtrium —	532 Uuq ununquadium —	533 Uub ununbium —	534 Uut ununtrium —	535 Uuq ununquadium —	536 Uub ununbium —	537 Uut ununtrium —	538 Uuq ununquadium —	539 Uub ununbium —	540 Uut 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40 A mixture of four different colourless amino acids is analysed by paper chromatography.

The final chromatogram is shown.



- Why does the chromatogram only show three spots?
- A A locating agent is **not** used.
 - B One of the amino acids is insoluble in the solvent.
 - C The solvent front is too near the top of the paper.
 - D Two of the amino acids have the same R_f value.

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

40 In paper chromatography, what is the equation for the R_f value?

A $R_f = \frac{\text{distance travelled by solvent}}{\text{distance travelled by substance}}$

B $R_f = \frac{\text{distance travelled by locating agent}}{\text{distance travelled by substance}}$

C $R_f = \frac{\text{distance travelled by substance}}{\text{distance travelled by locating agent}}$

D $R_f = \frac{\text{distance travelled by substance}}{\text{distance travelled by solvent}}$

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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 dm³ at room temperature and pressure (r.t.p.).

40 A mixture of soluble substances can be separated by paper chromatography. Each substance can be identified using its R_f value.

Which formula shows how the R_f value is calculated?

- A $R_f = \frac{\text{distance travelled by solvent}}{\text{distance travelled by substance}}$
- B $R_f = \frac{\text{distance travelled by substance}}{\text{distance travelled by solvent}}$
- C $R_f = \text{distance travelled by solvent} - \text{distance travelled by substance}$
- D $R_f = \text{distance travelled by solvent} \times \text{distance travelled by substance}$

The Periodic Table of Elements

Group																	
I	II	Key										III	IV	V	VI	VII	VIII
		atomic number name relative atomic mass										1 H hydrogen 1					
3 Li lithium 7	4 Be beryllium 9											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											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
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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 —	

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