

Cambridge
IGCSE

Cambridge International Examinations
Cambridge International General Certificate of Secondary Education

CANDIDATE
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CHEMISTRY

0620/32

Paper 3 (Extended)

October/November 2015

1 hour 15 minutes

Candidates answer on the Question Paper.

No Additional Materials are required.

READ THESE INSTRUCTIONS FIRST

Write your Centre number, candidate number and name on all the work you hand in.

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.

A copy of the Periodic Table is printed on page 12.

You may lose marks if you do not show your working or if you do not use appropriate units.

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.

The syllabus is approved for use in England, Wales and Northern Ireland as a Cambridge International Level 1/Level 2 Certificate.

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

2

1 Use your copy of the Periodic Table to help you answer some of these questions.

(a) Predict the formulae of the following compounds.

(i) nitrogen fluoride

(ii) phosphorus sulfide

[2]

(b) Deduce the formulae of the following ions.

(i) selenide

(ii) gallium

[2]

(c) Use the following ions to determine the formulae of the compounds.

ions OH^- Cr^{3+} Ba^{2+} SO_4^{2-}

compounds

(i) chromium(III) sulfate

(ii) barium hydroxide

[2]

[Total: 6]

2 (a) Polluted air contains two oxides of carbon and two oxides of nitrogen. A major source of these pollutants is motor vehicles.

(i) Describe how carbon dioxide and carbon monoxide are formed in motor vehicle engines.

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

(ii) State **one** adverse effect of each of these gases.

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

(iii) Nitrogen monoxide, NO, is released by motor vehicle exhausts.

Explain how nitrogen monoxide is formed in motor vehicle engines.

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

(iv) When nitrogen monoxide is released into the atmosphere, nitrogen dioxide, NO₂, is formed.

Suggest an explanation why this happens.

..... [1]

(b) Predict the possible adverse effect on the environment when this non-metal oxide, NO₂, reacts with water and oxygen.

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

(c) How are the amounts of carbon monoxide and nitrogen monoxide emitted by modern motor vehicles reduced? Include an equation in your answer.

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

[Total: 13]

- 3 Two of the main uses of zinc are for galvanising and for making alloys.

One of the main ores of zinc is zinc blende, ZnS. There are two stages in the extraction of zinc from this ore.

- (a) Stage 1** Zinc oxide is made from zinc blende.

Describe how this is done and write a word equation for the reaction.

.....

 [2]

- (b) Stage 2** Zinc oxide is reduced to zinc.

Write a word equation for the reduction of zinc oxide by coke.

..... [1]

- (c)** The zinc produced by this process is impure. It can be purified by electrolysis using a method which is similar to the purification of copper. Under the conditions used in the process, zinc is the product at the negative electrode (cathode).

Complete the following description of this purification.

The electrolyte is aqueous [1]

The negative electrode (cathode) is made of [1]

The positive electrode (anode) is impure zinc.

The equation for the reaction at the cathode is [1]

The equation for the reaction at the anode is [1]

Explain why the concentration of the electrolyte does **not** change.

.....
 [2]

(d) Brass is an alloy which contains zinc.

(i) Name the other metal in brass.

..... [1]

(ii) Suggest **two** reasons why an alloy such as brass is preferred to either of its constituent metals.

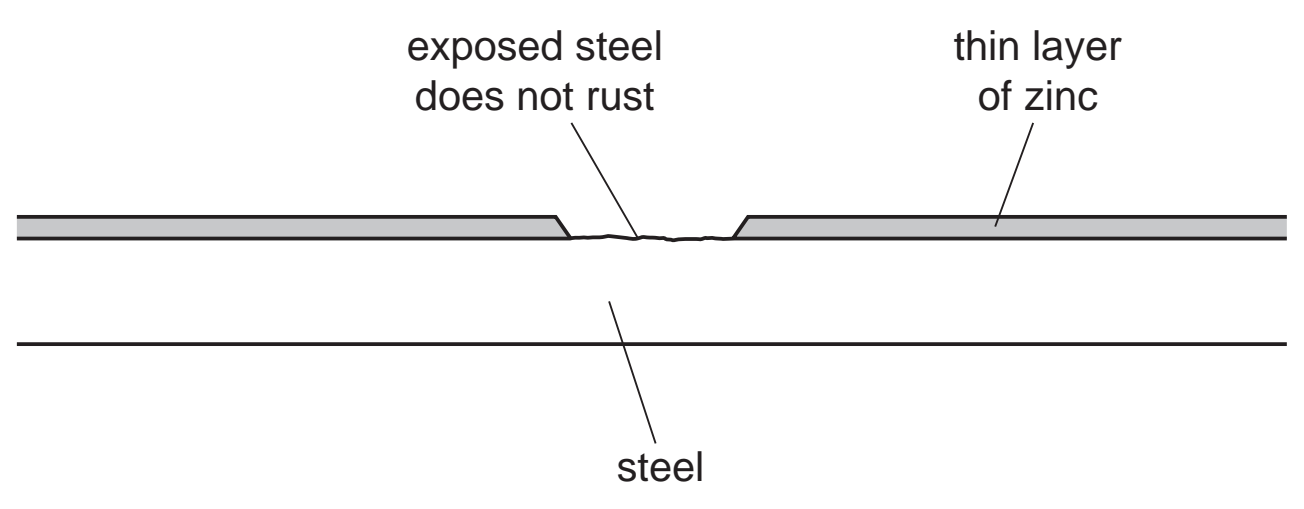
.....
..... [2]

(e) In an experiment to investigate the rate of rusting of steel, three pieces of steel were used. One piece of steel was completely coated with copper, one piece completely coated with zinc and the third piece was left uncoated. All three pieces were left exposed to the atmosphere.

(i) Explain why the uncoated piece started to rust.

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

(ii) The coating on both of the other two pieces was scratched, exposing the steel.



The piece of steel coated with zinc still did not rust but the copper-coated piece of steel rusted very rapidly.

Explain these observations in terms of the formation of ions and the transfer of electrons.

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

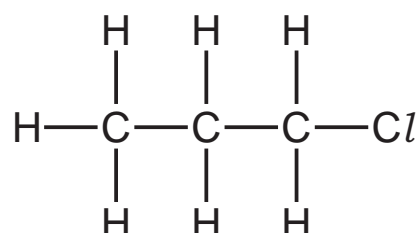
[Total: 17]

4 (a) Propane reacts with chlorine to form a mixture of chloropropanes. This is a photochemical reaction.

(i) What is meant by the phrase *photochemical reaction*?

.....
 [1]

(ii) The products of this reaction include two isomers, one of which has the following structural formula.



Draw the structural formula of the other isomer.

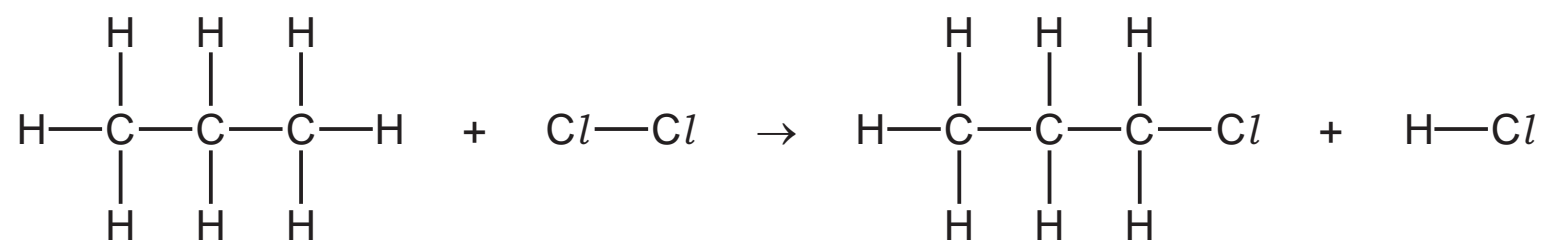
[1]

(iii) Explain why these two different compounds are isomers.

.....
 [2]

(b) Bond breaking is an endothermic change and bond forming is an exothermic change.

Bond energy is the amount of energy in kJ/mol needed to break one mole of the specified bond.



Use the following bond energies to determine whether this reaction is exothermic or endothermic. You must show your reasoning.

| bond | bond energies in kJ/mol |
|-------|-------------------------|
| C-Cl | 338 |
| C-H | 412 |
| Cl-Cl | 242 |
| H-Cl | 431 |
| C-C | 348 |

.....

.....

.....

..... [3]

- (c) (i)** Chloropropane can be hydrolysed to propanol, $\text{CH}_3\text{CH}_2\text{CH}_2\text{OH}$, by sodium hydroxide.

Write the equation for this reaction.

..... [2]

- (ii)** Propanol can be dehydrated. It loses a water molecule to form a hydrocarbon.

Give the name and structural formula of this hydrocarbon.

name

structural formula

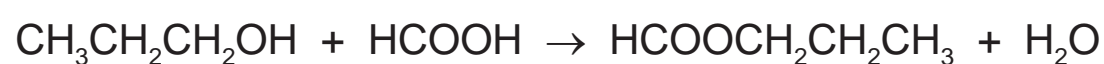
[2]

- (iii)** Propanol is oxidised to a carboxylic acid by acidified potassium manganate(VII).

Deduce the name of this acid.

..... [1]

- (d)** Propanol reacts with methanoic acid to form the ester propyl methanoate.



4.0g of methanoic acid was reacted with 6.0g of propanol.

- (i)** Calculate the M_r of methanoic acid = [1]

- (ii)** Calculate the M_r of propanol = [1]

- (iii)** Determine which one is the limiting reagent. Show your reasoning.

.....

.....

..... [2]

- (iv)** Calculate the maximum yield in grams of propyl methanoate, $M_r = 88$.

..... [1]

[Total: 17]

5 Iron is extracted from its ore, hematite, in a blast furnace.

Substances added to the furnace are:

- iron ore, hematite, containing impurities such as silica, SiO_2
- air
- coke, C
- limestone, CaCO_3

Substances formed in the blast furnace are:

- molten iron
- molten slag
- waste gases such as carbon dioxide

(a) State the **two** functions of the coke used in the blast furnace.

.....
 [2]

(b) Write an equation for the conversion of hematite, Fe_2O_3 , to iron.

..... [2]

(c) Explain how the silica impurity is removed and separated from the molten iron.

.....

 [3]

(d) The molten iron from the furnace is impure. It contains impurities which include the element carbon.

Explain how the carbon is removed. Include an equation in your answer.

.....

 [3]

[Total: 10]

- 6 The table below shows the elements in the third period of the Periodic Table, the number of electrons in their outer energy level, their oxidation state in their common compounds and their melting points.

| element | Na | Mg | Al | Si | P | S | Cl | Ar |
|---------------------------|----|-----|-----|-------|-----|-----|------|------|
| number of outer electrons | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
| oxidation state | +1 | +2 | +3 | +4/−4 | −3 | −2 | −1 | 0 |
| melting point/°C | 98 | 650 | 660 | 1414 | 317 | 115 | −101 | −189 |

- (a) Describe and explain the variation in oxidation state across the period.

.....

 [3]

- (b) The first three elements, Na, Mg and Al, are metals.

Describe the structure of a typical metal.

.....

 [3]

- (c) Explain why Na, Mg and Al are good conductors of electricity.

..... [1]

- (d) Which element exists as diatomic molecules of the type X_2 ?

..... [1]

- (e) Silicon has a similar structure to diamond.

Explain why silicon has the highest melting point in the period.

.....
 [2]

- (f)** Sodium chloride is a crystalline solid with a high melting point. It dissolves in water to give a neutral solution. Phosphorus trichloride is a liquid at room temperature. It reacts with water to form an acidic solution.

Suggest an explanation for these differences in properties.

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

- (g)** Describe how you could show that magnesium oxide is a basic oxide and not an amphoteric oxide.

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

- (h)** Draw a dot-and-cross diagram showing the bonding in magnesium oxide. Show outer electrons only.

[3]

[Total: 17]

DATA SHEET
The Periodic Table of the Elements

| | | Group | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
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| I | II | III | IV | V | VI | VII | O | | | | | O | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 7 Li Lithium 3 | 9 Be Beryllium 4 | 1 H Hydrogen 1 | 11 B Boron 5 | 12 C Carbon 6 | 13 Al Aluminium 13 | 14 N Nitrogen 7 | 15 O Oxygen 8 | 16 F Fluorine 9 | 17 Ne Neon 10 | 18 Ar Argon 18 | 19 K Potassium 19 | 20 Ca Calcium 20 | 21 Sc Scandium 21 | 22 Ti Titanium 22 | 23 V Vanadium 23 | 24 Cr Chromium 24 | 25 Mn Manganese 25 | 26 Fe Iron 26 | 27 Co Cobalt 27 | 28 Ni Nickel 28 | 29 Cu Copper 29 | 30 Zn Zinc 30 | 31 Ga Gallium 31 | 32 Ge Germanium 32 | 33 As Arsenic 33 | 34 Se Selenium 34 | 35 Br Bromine 35 | 36 Kr Krypton 36 | 37 Rb Rubidium 37 | 38 Sr Strontium 38 | 39 Y Yttrium 39 | 40 Zr Zirconium 40 | 41 Nb Niobium 41 | 42 Mo Molybdenum 42 | 43 Tc Technetium 43 | 44 Ru Ruthenium 44 | 45 Rh Rhodium 45 | 46 Pd Palladium 46 | 47 Ag Silver 47 | 48 Cd Cadmium 48 | 49 In Indium 49 | 50 Sn Tin 50 | 51 Sb Antimony 51 | 52 Te Tellurium 52 | 53 I Iodine 53 | 54 Xe Xenon 54 | 55 Cs Caesium 55 | 56 Ba Barium 56 | 57 La Lanthanum 57 | 58 Ce Cerium 58 | 59 Pr Praseodymium 59 | 60 Nd Neodymium 60 | 61 Pm Promethium 61 | 62 Sm Samarium 62 | 63 Eu Europium 63 | 64 Gd Gadolinium 64 | 65 Tb Terbium 65 | 66 Dy Dysprosium 66 | 67 Ho Holmium 67 | 68 Er Erbium 68 | 69 Tm Thulium 69 | 70 Yb Ytterbium 70 | 71 Lu Lutetium 71 | 72 Fr Francium 87 | 88 Ra Radium 88 | 89 Ac Actinium 89 | 90 Th Thorium 90 | 91 Pa Protactinium 91 | 92 U Uranium 92 | 93 Np Neptunium 93 | 94 Pu Plutonium 94 | 95 Am Americium 95 | 96 Cm Curium 96 | 97 Bk Berkelium 97 | 98 Cf Californium 98 | 99 Es Einsteinium 99 | 100 Fm Fermium 100 | 101 Md Mendelevium 101 | 102 No Nobelium 102 | 103 Lr Lawrencium 103 | 104 Rn Radon 86 | 105 At Astatine 85 | 106 Po Polonium 84 | 107 Bi Bismuth 83 | 108 Pb Lead 82 | 109 Tl Thallium 81 | 110 Hg Mercury 80 | 111 Au Gold 79 | 112 Pt Platinum 78 | 113 Ir Iridium 77 | 114 Rh Rhodium 76 | 115 Os Osmium 76 | 116 Re Rhenium 75 | 117 W Tungsten 74 | 118 Ta Tantalum 73 | 119 Hf Hafnium 72 | 120 Nb Niobium 71 | 121 Mo Molybdenum 70 | 122 Cr Chromium 69 | 123 Mn Manganese 68 | 124 Fe Iron 67 | 125 Co Cobalt 66 | 126 Ni Nickel 65 | 127 Cu Copper 64 | 128 Zn Zinc 63 | 129 Ga Gallium 62 | 130 Ge Germanium 61 | 131 As Arsenic 60 | 132 Se Selenium 59 | 133 Br Bromine 58 | 134 Kr Krypton 57 | 135 Rb Rubidium 56 | 136 Sr Strontium 55 | 137 Y Yttrium 54 | 138 Zr Zirconium 53 | 139 Nb Niobium 52 | 140 Mo Molybdenum 51 | 141 Cr Chromium 50 | 142 Mn Manganese 49 | 143 Fe Iron 48 | 144 Co Cobalt 47 | 145 Ni Nickel 46 | 146 Cu Copper 45 | 147 Zn Zinc 44 | 148 Ga Gallium 43 | 149 Ge Germanium 42 | 150 As Arsenic 41 | 151 Se Selenium 40 | 152 Br Bromine 39 | 153 Kr Krypton 38 | 154 Rb Rubidium 37 | 155 Sr Strontium 36 | 156 Y Yttrium 35 | 157 Zr Zirconium 34 | 158 Nb Niobium 33 | 159 Mo Molybdenum 32 | 160 Cr Chromium 31 | 161 Mn Manganese 30 | 162 Fe Iron 29 | 163 Co Cobalt 28 | 164 Ni Nickel 27 | 165 Cu Copper 26 | 166 Zn Zinc 25 | 167 Ga Gallium 24 | 168 Ge Germanium 23 | 169 As Arsenic 22 | 170 Se Selenium 21 | 171 Br Bromine 20 | 172 Kr Krypton 19 | 173 Rb Rubidium 18 | 174 Sr Strontium 17 | 175 Y Yttrium 16 | 176 Zr Zirconium 15 | 177 Nb Niobium 14 | 178 Mo Molybdenum 13 | 179 Cr Chromium 12 | 180 Mn Manganese 11 | 181 Fe Iron 10 | 182 Co Cobalt 9 | 183 Ni Nickel 8 | 184 Cu Copper 7 | 185 Zn Zinc 6 | 186 Ga Gallium 5 | 187 Ge Germanium 4 | 188 As Arsenic 3 | 189 Se Selenium 2 | 190 Br Bromine 1 | 191 Kr Krypton 0 | 192 Rb Rubidium -1 | 193 Sr Strontium -2 | 194 Y Yttrium -3 | 195 Zr Zirconium -4 | 196 Nb Niobium -5 | 197 Mo Molybdenum -6 | 198 Cr Chromium -7 | 199 Mn Manganese -8 | 200 Fe Iron -9 | 201 Co Cobalt -10 | 202 Ni Nickel -11 | 203 Cu Copper -12 | 204 Zn Zinc -13 | 205 Ga Gallium -14 | 206 Ge Germanium -15 | 207 As Arsenic -16 | 208 Se Selenium -17 | 209 Br Bromine -18 | 210 Kr Krypton -19 | 211 Rb Rubidium -20 | 212 Sr Strontium -21 | 213 Y Yttrium -22 | 214 Zr Zirconium -23 | 215 Nb Niobium -24 | 216 Mo Molybdenum -25 | 217 Cr Chromium -26 | 218 Mn Manganese -27 | 219 Fe Iron -28 | 220 Co Cobalt -29 | 221 Ni Nickel -30 | 222 Cu Copper -31 | 223 Zn Zinc -32 | 224 Ga Gallium -33 | 225 Ge Germanium -34 | 226 As Arsenic -35 | 227 Se Selenium -36 | 228 Br Bromine -37 | 229 Kr Krypton -38 | 230 Rb Rubidium -39 | 231 Sr Strontium -40 | 232 Y Yttrium -41 | 233 Zr Zirconium -42 | 234 Nb Niobium -43 | 235 Mo Molybdenum -44 | 236 Cr Chromium -45 | 237 Mn Manganese -46 | 238 Fe Iron -47 | 239 Co Cobalt -48 | 240 Ni Nickel -49 | 241 Cu Copper -50 | 242 Zn Zinc -51 | 243 Ga Gallium -52 | 244 Ge Germanium -53 | 245 As Arsenic -54 | 246 Se Selenium -55 | 247 Br Bromine -56 | 248 Kr Krypton -57 | 249 Rb Rubidium -58 | 250 Sr Strontium -59 | 251 Y Yttrium -60 | 252 Zr Zirconium -61 | 253 Nb Niobium -62 | 254 Mo Molybdenum -63 | 255 Cr Chromium -64 | 256 Mn Manganese -65 | 257 Fe Iron -66 | 258 Co Cobalt -67 | 259 Ni Nickel -68 | 260 Cu Copper -69 | 261 Zn Zinc -70 | 262 Ga Gallium -71 | 263 Ge Germanium -72 | 264 As Arsenic -73 | 265 Se Selenium -74 | 266 Br Bromine -75 | 267 Kr Krypton -76 | 268 Rb Rubidium -77 | 269 Sr Strontium -78 | 270 Y Yttrium -79 | 271 Zr Zirconium -80 | 272 Nb Niobium -81 | 273 Mo Molybdenum -82 | 274 Cr Chromium -83 | 275 Mn Manganese -84 | 276 Fe Iron -85 | 277 Co Cobalt -86 | 278 Ni Nickel -87 | 279 Cu Copper -88 | 280 Zn Zinc -89 | 281 Ga Gallium -90 | 282 Ge Germanium -91 | 283 As Arsenic -92 | 284 Se Selenium -93 | 285 Br Bromine -94 | 286 Kr Krypton -95 | 287 Rb Rubidium -96 | 288 Sr Strontium -97 | 289 Y Yttrium -98 | 290 Zr Zirconium -99 | 291 Nb Niobium -100 | 292 Mo Molybdenum -101 | 293 Cr Chromium -102 | 294 Mn Manganese -103 | 295 Fe Iron -104 | 296 Co Cobalt -105 | 297 Ni Nickel -106 | 298 Cu Copper -107 | 299 Zn Zinc -108 | 300 Ga Gallium -109 | 301 Ge Germanium -110 | 302 As Arsenic -111 | 303 Se Selenium -112 | 304 Br Bromine -113 | 305 Kr Krypton -114 | 306 Rb Rubidium -115 | 307 Sr Strontium -116 | 308 Y Yttrium -117 | 309 Zr Zirconium -118 | 310 Nb Niobium -119 | 311 Mo Molybdenum -120 | 312 Cr Chromium -121 | 313 Mn Manganese -122 | 314 Fe Iron -123 | 315 Co Cobalt -124 | 316 Ni Nickel -125 | 317 Cu Copper -126 | 318 Zn Zinc -127 | 319 Ga Gallium -128 | 320 Ge Germanium -129 | 321 As Arsenic -130 | 322 Se Selenium -131 | 323 Br Bromine -132 | 324 Kr Krypton -133 | 325 Rb Rubidium -134 | 326 Sr Strontium -135 | 327 Y Yttrium -136 | 328 Zr Zirconium -137 | 329 Nb Niobium -138 | 330 Mo Molybdenum -139 | 331 Cr Chromium -140 | 332 Mn Manganese -141 | 333 Fe Iron -142 | 334 Co Cobalt -143 | 335 Ni Nickel -144 | 336 Cu Copper -145 | 337 Zn Zinc -146 | 338 Ga Gallium -147 | 339 Ge Germanium -148 | 340 As Arsenic -149 | 341 Se Selenium -150 | 342 Br Bromine -151 | 343 Kr Krypton -152 | 344 Rb Rubidium -153 | 345 Sr Strontium -154 | 346 Y Yttrium -155 | 347 Zr Zirconium -156 | 348 Nb Niobium -157 | 349 Mo Molybdenum -158 | 350 Cr Chromium -159 | 351 Mn Manganese -160 | 352 Fe Iron -161 | 353 Co Cobalt -162 | 354 Ni Nickel -163 | 355 Cu Copper -164 | 356 Zn Zinc -165 | 357 Ga Gallium -166 | 358 Ge Germanium -167 | 359 As Arsenic -168 | 360 Se Selenium -169 | 361 Br Bromine -170 | 362 Kr Krypton -171 | 363 Rb Rubidium -172 | 364 Sr Strontium -173 | 365 Y Yttrium -174 | 366 Zr Zirconium -175 | 367 Nb Niobium -176 | 368 Mo Molybdenum -177 | 369 Cr Chromium -178 | 370 Mn Manganese -179 | 371 Fe Iron -180 | 372 Co Cobalt -181 | 373 Ni Nickel -182 | 374 Cu Copper -183 | 375 Zn Zinc -184 | 376 Ga Gallium -185 | 377 Ge Germanium -186 | 378 As Arsenic -187 | 379 Se Selenium -188 | 380 Br Bromine -189 | 381 Kr Krypton -190 | 382 Rb Rubidium -191 | 383 Sr Strontium -192 | 384 Y Yttrium -193 | 385 Zr Zirconium -194 | 386 Nb Niobium -195 | 387 Mo Molybdenum -196 | 388 Cr Chromium -197 | 389 Mn Manganese -198 | 390 Fe Iron -199 | 391 Co Cobalt -200 | 392 Ni Nickel -201 | 393 Cu Copper -202 | 394 Zn Zinc -203 | 395 Ga Gallium -204 | 396 Ge Germanium -205 | 397 As Arsenic -206 | 398 Se Selenium -207 | 399 Br Bromine -208 | 400 Kr Krypton -209 | 401 Rb Rubidium -210 | 402 Sr Strontium -211 | 403 Y Yttrium -212 | 404 Zr Zirconium -213 | 405 Nb Niobium -214 | 406 Mo Molybdenum -215 | 407 Cr Chromium -216 | 408 Mn Manganese -217 | 409 Fe Iron -218 | 410 Co Cobalt -219 | 411 Ni Nickel -220 | 412 Cu Copper -221 | 413 Zn Zinc -222 | 414 Ga Gallium -223 | 415 Ge Germanium -224 | 416 As Arsenic -225 | 417 Se Selenium -226 | 418 Br Bromine -227 | 419 Kr Krypton -228 | 420 Rb Rubidium -229 | 421 Sr Strontium -230 | 422 Y Yttrium -231 | 423 Zr Zirconium -232 | 424 Nb Niobium -233 | 425 Mo Molybdenum -234 | 426 Cr Chromium -235 | 427 Mn Manganese -236 | 428 Fe Iron -237 | 429 Co Cobalt -238 | 430 Ni Nickel -239 | 431 Cu Copper -240 | 432 Zn Zinc -241 | 433 Ga Gallium -242 | 434 Ge Germanium -243 | 435 As Arsenic -244 | 436 Se Selenium -245 | 437 Br Bromine -246 | 438 Kr Krypton -247 | 439 Rb Rubidium -248 | 440 Sr Strontium -249 | 441 Y Yttrium -250 | 442 Zr Zirconium -251 | 443 Nb Niobium -252 | 444 Mo Molybdenum -253 | 445 Cr Chromium -254 | 446 Mn Manganese -255 | 447 Fe Iron -256 | 448 Co Cobalt -257 | 449 Ni Nickel -258 | 450 Cu Copper -259 | 451 Zn Zinc -260 | 452 Ga Gallium -261 | 453 Ge Germanium -262 | 454 As Arsenic -263 | 455 Se Selenium -264 | 456 Br Bromine -265 | 457 Kr Krypton -266 | 458 Rb Rubidium -267 | 459 Sr Strontium -268 | 460 Y Yttrium -269 | 461 Zr Zirconium -270 | 462 Nb Niobium -271 | 463 Mo Molybdenum -272 | 464 Cr Chromium -273 | 465 Mn Manganese -274 | 466 Fe Iron -275 | 467 Co Cobalt -276 | 468 Ni Nickel -277 | 469 Cu Copper -278 | 470 Zn Zinc -279 | 471 Ga Gallium -280 | 472 Ge Germanium -281 | 473 As Arsenic -282 | 474 Se Selenium -283 | 475 Br Bromine -284 | 476 Kr Krypton -285 | 477 Rb Rubidium -286 | 478 Sr Strontium -287 | 479 Y Yttrium -288 | 480 Zr Zirconium -289 | 481 Nb Niobium -290 | 48 |