THE OPEN UNIVERSITY OF SRI LANKA

DIPLOMA IN TECHNOLOGY - LEVEL 01

FINAL EXAMINATION 2008

CEX1330 - ENGINEERING PROPERTIES OF MATERIALS

Time allowed: 3 Hours Index Number:

Date: 02nd May, 2008 Time: 9:30-12:30 hrs.

Note: The Periodic table is given on the last page for reference.

**PART A:**

Answer all questions. Each question carries 2.5 marks and the mark for Part A makes up 30% of the total mark.

1. Compute the length of a 'simple pendulum' which passes through its lowest point once every second.
2. A parachutist of weight 700N falls at constant velocity. Determine the upward force on the parachutist. Draw the free body diagram for the parachutist indicating all the forces.
3. Out in deep space, far from any celestial object that exerts significant gravity, would an astronaut weigh anything? Would the astronaut have a mass? Explain your answer.
4. If a nuclear reaction adds an extra neutron to the nucleus of $^{57}Fe$ (a stable isotope of iron), it produces $^{58}Fe$ (another stable isotope of iron). How will this change in the nucleus affect the number and arrangement of the electrons in the atom that's built around this nucleus? State the electron configuration for $^{58}Fe$ isotope. Determine the number of protons and neutrons in the nuclei of $^{58}Fe$ isotope.
5. A good hacksaw blade costs around sixty rupees. You could also purchase a cheaper version for five rupees. Explain how such blades generally fail. Compare the differences in engineering properties for the two types. List two instances in which the expensive type is preferred.
6. If you pull slowly on the top sheet of a pad of paper, the whole pad will move. But if you yank suddenly on that sheet, it will tear away from the pad. Explain the cause for this type of behaviour.
7. Describe the process of writing with chalk on a black board in terms of friction and

wear.

8. Crystals of sodium chloride and diamond both have transparent structures. Using your knowledge of bonding and the structures of these two materials, explain why one is hard, insoluble and a poor conductor of electricity, whereas the other is soluble in water and conducts electricity under certain circumstances.
9. Concrete structures are reinforced with steel bars. Explain why concrete should be reinforced and why steel is used as reinforcement material.
10. The atomic nucleus occupies a minute space and the electrons are revolving around it. The bonding between atoms is mainly attractions and no physical connection between atoms. Explain why one cannot penetrate a solid wooden door, which is made of a collection of such atoms.
11. Explain why granular materials form a heap when poured on to a horizontal surface.
12. Conductivity of semi conductors increases with temperature, while that of the good conductors decrease marginally with increase of temperature. Explain why.

**PART B:**

Answer 4 questions. Each question carries 17.5 marks and the mark for part B makes up 70% of the total mark.

1.

a.

i. Measuring instruments are frequently calibrated. Explain the process of calibration. (02 marks)

ii. Parents often check whether their children have fever by touching the neck/forehead of the child with the back of the hand.

a) State what exactly they check in this manner. Discuss whether this method of checking the temperature is reliable. (02 marks)

b) Suggest how this method of checking the temperature can be improved. (02 marks)

b. Vernier calipers are used in measuring small lengths accurately. A vernier caliper has been used to measure the depth of a small cylindrical object. The observed reading is shown in figure 1(b).

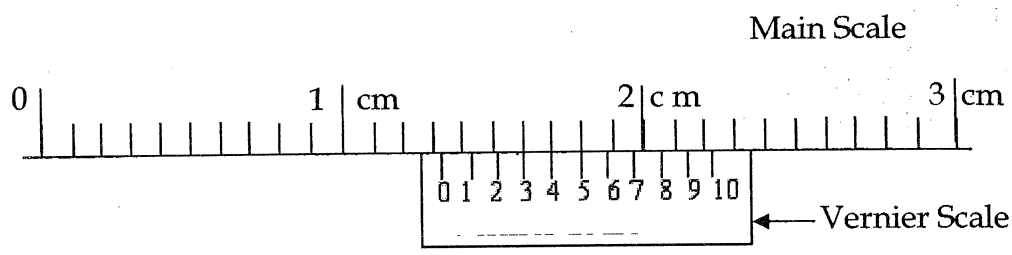



Figure 1(b)

i) Determine the least count of the given vernier caliper. (01 mark)

ii) Find the depth of the cylindrical object. (02 marks)

iii) Suppose that you want to compute the volume of the cylindrical object, state the other measurements that should be made. (01 mark)

iv) Explain how you observe the 'zero error' in the vernier calliper. (01 mark)

c. You are riding on a play ground swing, swinging back and forth once every few seconds.

i) Sketch this motion; indicate the point(s) where velocity becomes zero. (1.5 marks)

ii) Indicate the point(s) at which your gravitational potential energy is at its maximum. (01 mark)

iii) Indicate the point(s) at which your kinetic energy is at its maximum. (01 mark)

iv) As you reach the bottom of the swing, when the swing's ropes are vertical, are you accelerating? (1.5 marks)

v) As you swing back and forth, your apparent weight changes. Indicate the point where you feel heaviest. (1.5 marks)

2.

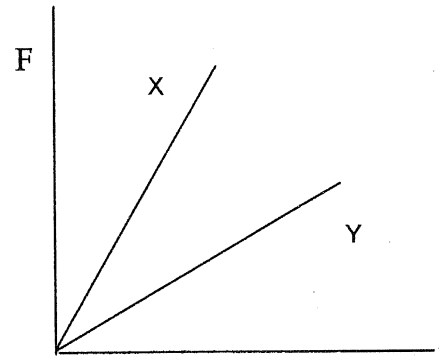



Figure 2(a)

a. Figure 2(a) shows the variation of F, the load applied to two wires X and Y, and their extension e. The wires are both made of iron and have the same length.

i) Find which wire has the smaller cross section. (2 marks)

ii) Explain how you would use the graph for X to obtain a value for the Young modulus of iron. List the additional measurements you need to take. (3 marks)

b. A light rigid bar is suspended horizontally from two vertical wires, one of steel and one of brass, as shown in figure 2(b). Each wire is 2 m long. The diameter of the steel wire is 0.6 mm and the length of the bar AB is 0.2 m. When a mass of 10.0 kg is suspended from the centre of AB the bar remains horizontal.

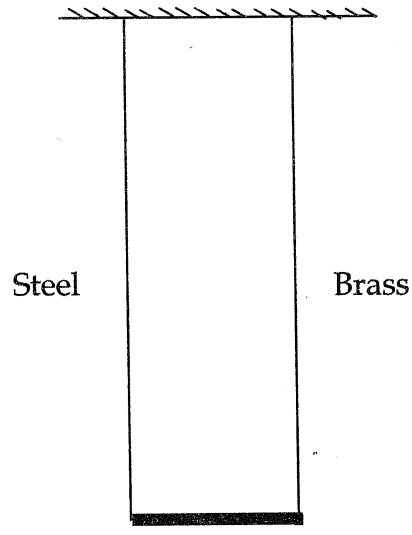



Figure 2(b)

i) Find the tension in each wire. (2 marks)

ii) Calculate the extension of the steel wire and the energy stored in it. (2 marks)

iii) Calculate the diameter of the brass wire. (1.5 marks)

iv) If the brass wire was replaced by another brass wire of diameter 1 mm, determine the place where the mass be suspended so that AB would remain horizontal. (2 marks)

(Young modulus for steel = $2.0 \times 10^{11}$ Pa and Young modulus for brass = $1.0 \times 10^{11}$ Pa)

c. A bicycle and a rider have a combined mass of 90 kg. Assume that the maximum frictional force between the rear wheel and the ground is 80% of the perpendicular contact force at that wheel.

i) Sketch a free body diagram showing all the forces acting on the accelerating bicycle and the rider. (2 marks)

ii) Calculate the friction force. (2 marks)

iii) Determine the acceleration that the rider is riding his bicycle at. State any laws you have used. (2 marks)

iv) Is the acceleration that you obtained in (iii), the riders maximum acceleration? If not at what instant the rider will have the maximum acceleration? (2 marks)

3.

Figure 3(a)

a. The frame of the pushchair illustrated in was fabricated from stainless steel tubing.

i) State the properties that make the stainless steel particularly suitable for this product. (2 marks)

ii) Explain the reason behind the usage of tubing rather than solid bar. (2 marks)

iii) List two disadvantages of using mild steel for this product. (2 marks)

iv) Some push chairs are made from aluminium. State one advantage and one disadvantage of using aluminium for this product. (2 marks)

b. Copper is a pure metal. It is the world's third most important metal, in terms of volume of consumption.

i) State the electronic configuration of copper. (1 marks)

ii) Describe the bonding in copper metal and hence explain why it is selected for the following applications.

a) Copper wire in electrical appliances

b) Car radiator core

c) Electric motor windings

d) Boilers (2 marks)

iii) Give two examples where the addition of another material improves some desirable property copper. For each example list the material added and the property improved. (2 marks)

iv) The atomic weight of copper is 63.54 and the atomic radius of copper is $1.276 \times 10^{-10}$ m. Copper crystallizes as Face Centred Cubic structure (FCC). Avogadro's number, is $6.023 \times 10^{23}$.

a) Calculate the lattice parameter of copper. (2 marks)

b) Determine the density of copper. (2.5 marks)

4.

a. The gas equation can be given by the following form,

$$\left((P+\frac{a}{V^2})(V-b)=RT\right)$$

where

P - Pressure, V – Volume, T - absolute temperature

i) State the difference between a unit and a dimension. (1 marks)

ii) List the SI units and dimensions for P and V. (2 marks)

iii) Determine the dimensions of constants a and b. (2.5 marks)

iv) If the absolute temperature (T) is measured in Kelvin, derive the units of the gas constant R. (2 marks)

b) What we commonly refer to as "sand" is made up of grains of quartz – which is a crystalline form of Silicon Dioxide ($SiO_2$). Quartz has a density of about 2,650 kg/m$^3$. It is found that well compacted sand grains of uniform size (all the grains are approximately the same size) has a porosity of about 30% , regardless of the grain size.

i) Explain what is meant by porosity. (2 marks)

ii) Explain why the porosity of well compacted sand of uniform grain size does not vary much with the size of the grains. (2 marks)

iii) Calculate the approximate number of sand grains having a uniform size of 2 mm that would be required to fill Container A, that has a volume of 20 litres. You can assume that the grains are spherical, with a diameter equal to the given size and that the sand is well compacted. (2 marks)

iv) Calculate the approximate number of sand grains having a uniform size of 0.2 mm that would be required to fill a Container B, that has a volume of 20 litres. You can assume that the grains are spherical, with a diameter equal to the given size and that the sand is well compacted. (2 marks)

v) The contents of Containers A and B are poured into Container C, which has a volume of 50 litres. Container C is shaken well. Will the volume of the mixture of sands in Container C be less than, equal to or greater than 40 litres? Explain your answer. (2 marks)

5.

a. The plot of first ionization energies against atomic number for the elements of atomic number 4 to 9 is given in figure 5(a).

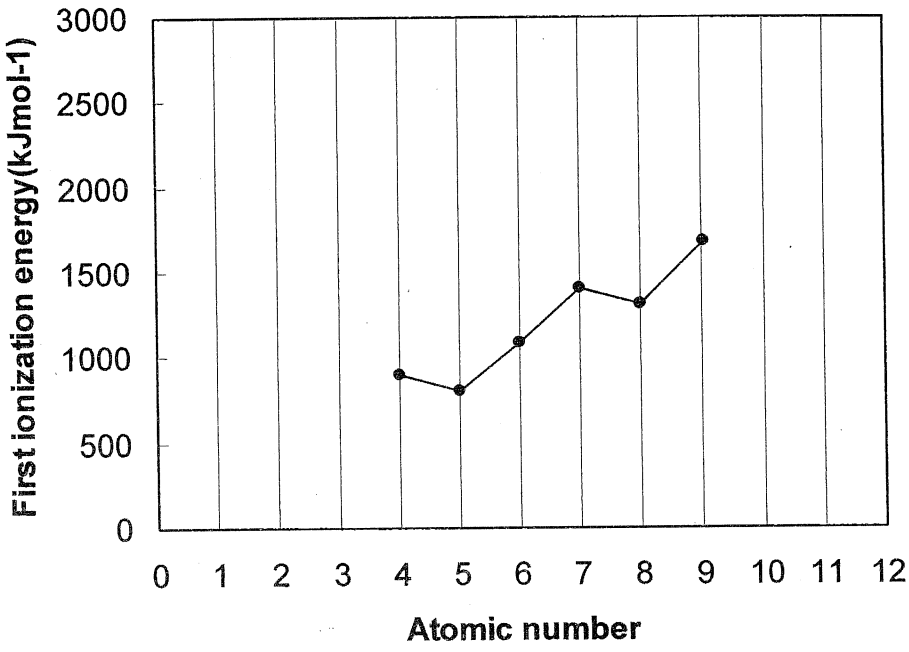



Figure 5(a)

i) Show on the plot where you would expect the first ionization energies of the elements of atomic number 3 and 10 . (2 marks)

ii) How would you expect the first ionization energy of element of atomic number 11 to compare with that of element of atomic number 3? (2 marks)

iii) Give reasons for the fall in first ionisation energy between element of atomic number 7 and element of atomic number 8. (2 marks)

b.

i) Helium has the highest first ionization energy in the periodic table. Suggest the element which is likely to have the lowest first ionization energy. (1.5 marks)

ii) In each of the following pairs of atoms/ions which is larger?

(a) Na and $Na^+$ (b) Si and P

(c) Br and $Br^-$ (d) F and I (2 marks)

iii) Find the number of protons, neutrons and electrons in the following and determine their electronic configuration.

(a) $^{56}_{26}Fe$ b) $^{32}_{16}S^{2-}$ (2 marks)

c. The Figure 4(c) below represents the Periodic Table, with four areas denoted by 1, 2, 3, 4.

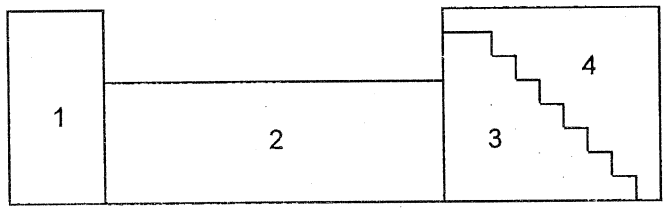



Figure 4(c)

i) Which area 1, 2, 3 or 4, is most likely to contain non - metals? (1.5 marks)

ii) Which area is most likely to contain metals with melting points over 1000$^0$C? (1.5 marks)

iii) Which area is most likely to contain elements with oxides which dissolve in water to produce basic solutions? (1.5 marks)

iv) Which area is most likely to contain elements which form coloured ions? (1.5 marks)

6.

a. The concentration of a solution of lime water ($Ca(OH)_2$ , saturated aqueous calcium hydroxide) was determined by titrating 25.0 $cm^3$ of the solution with 0.0200 $moldm^{-3}$ hydrochloric acid. 21.4 $cm^3$ of the acid was needed at the end point.

i) Write down the equilibrium equation for the above case. (2 marks)

ii) Calculate the concentration of the lime water. (2 marks)

iii) State two errors that can occur during titration and the precautions that can be taken to reduce the errors. (2 marks)

iv) Lime water can be used to test for carbon dioxide.

a) Write down the equilibrium equation for the above case. (1.5 marks)

b) Calculate the volume of carbon dioxide which can be absorbed by 1 $dm^3$ of lime water. (1 mole of a gas occupies 24 $dm^3$ at room temperature and pressure). (1.5 marks)
(1dm=10cm)

b. Sodium is a silvery grey metal. It has to be kept under oil because it reacts rapidly with oxygen and water vapour in the air. Chlorine is a poisonous green gas. Sodium chloride is a white, crystalline solid which we eat as table salt.

i) Explain how the sodium in sodium chloride differs from sodium metal.
(1.5 marks)

ii) Explain how the chlorine in sodium chloride differs from chorine gas.
(1.5 marks)

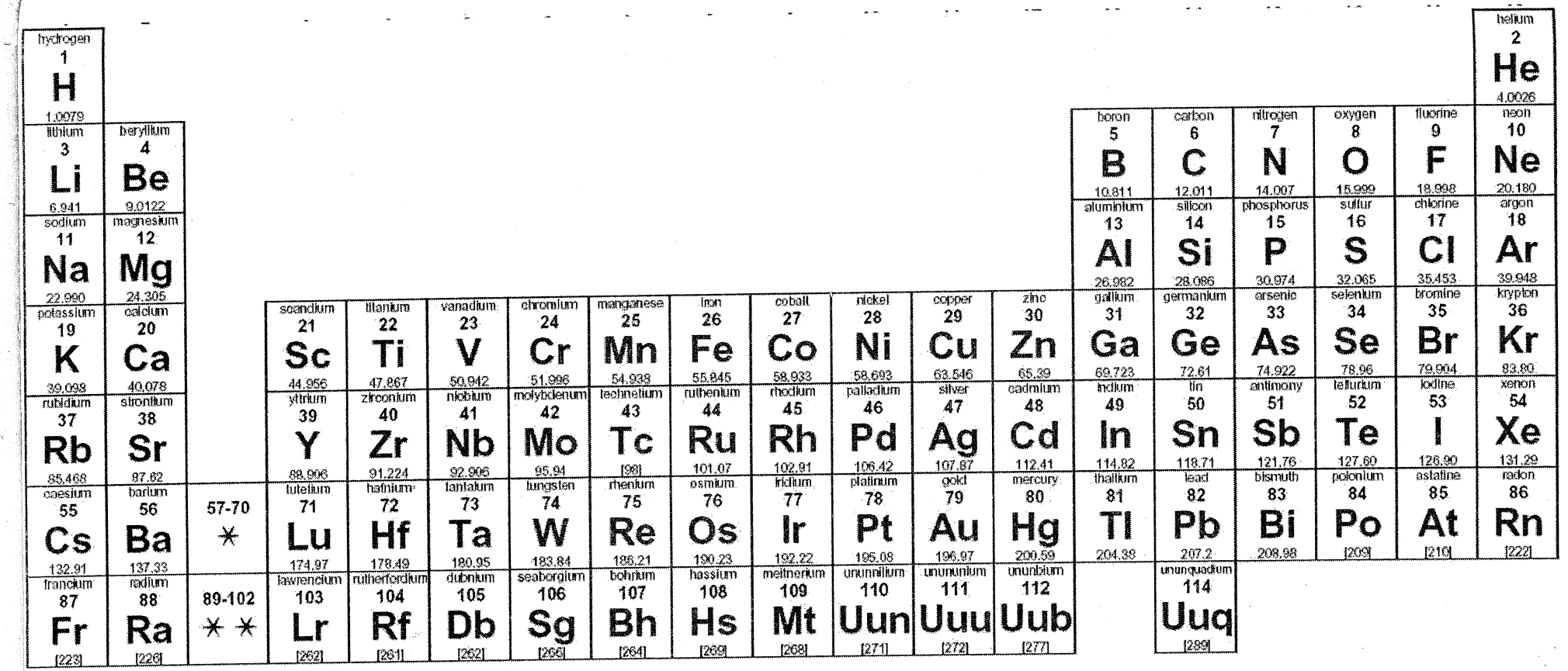
iii) Find the charge of the Sodium chloride crystal.
(1 mark)

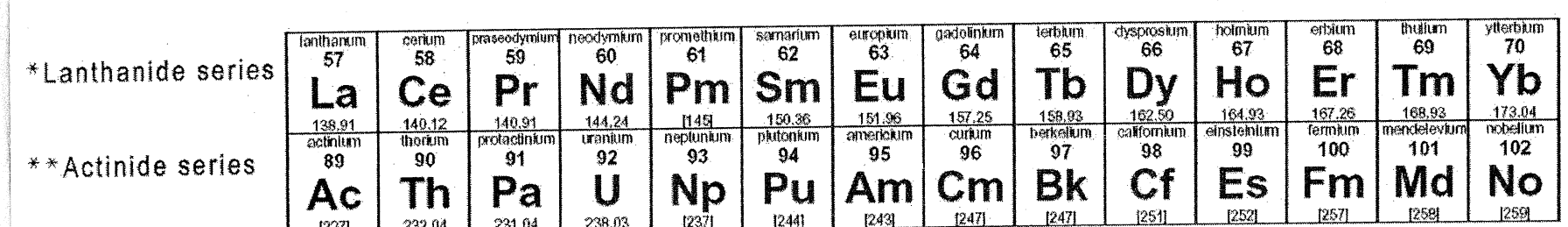
iv) Comment on the melting and boiling points of the solid sodium chloride.
(1.5 marks)

v) Explain why it readily dissolves in water.
(1.5 marks)

vi) Explain why solid sodium chloride does not conduct electricity.
(1.5 marks)

xxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxx


hydrogen 1 H 1.0079
helium 2 He 4.0026
lithium 3 Li 6.941
beryllium 4 Be 9.0122
boron 5 B 10.811
carbon 6 C 12.011
nitrogen 7 N 14.007
oxygen 8 O 15.999
fluorine 9 F 18.998
neon 10 Ne 20.180
sodium 11 Na 22.990
magnesium 12 Mg 24.305
aluminium 13 Al 26.982
silicon 14 Si 28.086
phosphorus 15 P 30.974
sulfur 16 S 32.065
chlorine 17 Cl 35.453
argon 18 Ar 39.948
potassium 19 K 39.098
calcium 20 Ca 40.078
scandium 21 Sc 44.956
titanium 22 Ti 47.867
vanadium 23 V 50.942
chromium 24 Cr 51.996
manganese 25 Mn 54.938
iron 26 Fe 55.845
cobalt 27 Co 58.933
nickel 28 Ni 58.693
copper 29 Cu 63.546
zinc 30 Zn 65.39
gallium 31 Ga 69.723
germanium 32 Ge 72.61
arsenic 33 As 74.922
selenium 34 Se 78.96
bromine 35 Br 79.904
krypton 36 Kr 83.80
rubidium 37 Rb 85.468
strontium 38 Sr 87.62
yttrium 39 Y 88.906
zirconium 40 Zr 91.224
niobium 41 Nb 92.906
molybdenum 42 Mo 95.94
technetium 43 Tc [98]
ruthenium 44 Ru 101.07
rhodium 45 Rh 102.91
palladium 46 Pd 106.42
silver 47 Ag 107.87
cadmium 48 Cd 112.41
indium 49 In 114.82
tin 50 Sn 118.71
antimony 51 Sb 121.76
tellurium 52 Te 127.60
iodine 53 I 126.90
xenon 54 Xe 131.29
caesium 55 Cs 132.91
barium 56 Ba 137.33
57-70 ✳
lutetium 71 Lu 174.97
hafnium 72 Hf 178.49
tantalum 73 Ta 180.95
tungsten 74 W 183.84
rhenium 75 Re 186.21
osmium 76 Os 190.23
iridium 77 Ir 192.22
platinum 78 Pt 195.08
gold 79 Au 196.97
mercury 80 Hg 200.59
thallium 81 Tl 204.38
lead 82 Pb 207.2
bismuth 83 Bi 208.98
polonium 84 Po [209]
astatine 85 At [210]
radon 86 Rn [222]
francium 87 Fr [223]
radium 88 Ra [226]
89-102 ✳✳
lawrencium 103 Lr [262]
rutherfordium 104 Rf [261]
dubnium 105 Db [262]
seaborgium 106 Sg [266]
bohrium 107 Bh [264]
hassium 108 Hs [269]
meitnerium 109 Mt [268]
ununnilium 110 Uun [271]
unununium 111 Uuu [272]
ununbium 112 Uub [277]
ununquadium 114 Uuq [289]


*Lanthanide series
**Actinide series
lanthanum 57 La 138.91
cerium 58 Ce 140.12
praseodymium 59 Pr 140.91
neodymium 60 Nd 144.24
promethium 61 Pm [145]
samarium 62 Sm 150.36
europium 63 Eu 151.96
gadolinium 64 Gd 157.25
terbium 65 Tb 158.93
dysprosium 66 Dy 162.50
holmium 67 Ho 164.93
erbium 68 Er 167.26
thulium 69 Tm 168.93
ytterbium 70 Yb 173.04
actinium 89 Ac [227]
thorium 90 Th 232.04
protactinium 91 Pa 231.04
uranium 92 U 238.03
neptunium 93 Np [237]
plutonium 94 Pu [244]
americium 95 Am [243]
curium 96 Cm [247]
berkelium 97 Bk [247]
californium 98 Cf [251]
einsteinium 99 Es [252]
fermium 100 Fm [257]
mendelevium 101 Md [258]
nobelium 102 No [259]