N5

RADIATION

Practice Exam Questions

Physics
Section 1—Questions

DATA SHEET

Speed of light in materials

Material	*Speed* in m s^{-1}
Air	$3{\cdot}0 \times 10^8$
Carbon dioxide	$3{\cdot}0 \times 10^8$
Diamond	$1{\cdot}2 \times 10^8$
Glass	$2{\cdot}0 \times 10^8$
Glycerol	$2{\cdot}1 \times 10^8$
Water	$2{\cdot}3 \times 10^8$

Gravitational field strengths

	Gravitational field strength on the surface in N kg^{-1}
Earth	9·8
Jupiter	23
Mars	3·7
Mercury	3·7
Moon	1·6
Neptune	11
Saturn	9·0
Sun	270
Uranus	8·7
Venus	8·9

Specific latent heat of fusion of materials

Material	*Specific latent heat of fusion* in J kg^{-1}
Alcohol	$0{\cdot}99 \times 10^5$
Aluminium	$3{\cdot}95 \times 10^5$
Carbon Dioxide	$1{\cdot}80 \times 10^5$
Copper	$2{\cdot}05 \times 10^5$
Iron	$2{\cdot}67 \times 10^5$
Lead	$0{\cdot}25 \times 10^5$
Water	$3{\cdot}34 \times 10^5$

Specific latent heat of vaporisation of materials

Material	*Specific latent heat of vaporisation* in J kg^{-1}
Alcohol	$11{\cdot}2 \times 10^5$
Carbon Dioxide	$3{\cdot}77 \times 10^5$
Glycerol	$8{\cdot}30 \times 10^5$
Turpentine	$2{\cdot}90 \times 10^5$
Water	$22{\cdot}6 \times 10^5$

Speed of sound in materials

Material	*Speed* in m s^{-1}
Aluminium	5200
Air	340
Bone	4100
Carbon dioxide	270
Glycerol	1900
Muscle	1600
Steel	5200
Tissue	1500
Water	1500

Specific heat capacity of materials

Material	*Specific heat capacity* in J kg^{-1} °C^{-1}
Alcohol	2350
Aluminium	902
Copper	386
Glass	500
Ice	2100
Iron	480
Lead	128
Oil	2130
Water	4180

Melting and boiling points of materials

Material	*Melting point* in °C	*Boiling point* in °C
Alcohol	−98	65
Aluminium	660	2470
Copper	1077	2567
Glycerol	18	290
Lead	328	1737
Iron	1537	2737

Radiation weighting factors

Type of radiation	*Radiation weighting factor*
alpha	20
beta	1
fast neutrons	10
gamma	1
slow neutrons	3
X-rays	1

10. Which row describes alpha (α), beta (β) and gamma (γ) radiations?

	α	β	γ
A	helium nucleus	electromagnetic radiation	electron from the nucleus
B	helium nucleus	electron from the nucleus	electromagnetic radiation
C	electron from the nucleus	helium nucleus	electromagnetic radiation
D	electromagnetic radiation	helium nucleus	electron from the nucleus
E	electromagnetic radiation	electron from the nucleus	helium nucleus

11. A sample of tissue is irradiated using a radioactive source.

A student makes the following statements about the sample.

I The equivalent dose received by the sample is reduced by shielding the sample with a lead screen.

II The equivalent dose received by the sample is increased as the distance from the source to the sample is increased.

III The equivalent dose received by the sample is increased by increasing the time of exposure of the sample to the radiation.

Which of these statements is/are correct?

A I only

B II only

C I and II only

D II and III only

E I and III only

12. The half-life of a radioactive source is 64 years.

In 2 hours, $1{\cdot}44 \times 10^8$ radioactive nuclei in the source decay.

What is the activity of the source in Bq?

A 2×10^4

B 4×10^4

C $1{\cdot}2 \times 10^6$

D $2{\cdot}25 \times 10^6$

E $7{\cdot}2 \times 10^7$

13. A student makes the following statements about the fission process in a nuclear power station.

I Electrons are used to bombard a uranium nucleus.

II Heat is produced.

III The neutrons released can cause other nuclei to undergo fission.

Which of these statements is/are correct?

A I only

B II only

C III only

D I and II only

E II and III only

9. Alpha radiation ionises an atom.

Which statement describes what happens to the atom?

A The atom splits in half.

B The atom releases a neutron.

C The atom becomes positively charged.

D The atom gives out gamma radiation.

E The atom releases heat.

12. For a particular radioactive source, 240 atoms decay in 1 minute.

The activity of this source is

A 4 Bq

B 180 Bq

C 240 Bq

D 300 Bq

E 14 400 Bq.

10. A sample of tissue is irradiated using a radioactive source.

A student makes the following statements.

The equivalent dose received by the tissue is

I reduced by shielding the tissue with a lead screen

II increased as the distance from the source to the tissue is increased

III increased by increasing the time of exposure of the tissue to the radiation.

Which of the statements is/are correct?

A I only

B II only

C I and II only

D II and III only

E I and III only

11. A sample of tissue receives an absorbed dose of 16 μGy from alpha particles.

The radiation weighting factor for alpha particles is 20.

The equivalent dose received by the sample is

A 0·80 μSv

B 1·25 μSv

C 4 μSv

D 36 μSv

E 320 μSv.

13. The letters **X, Y** and **Z** represent missing words from the following passage.

During a nuclear ……X…… *reaction two nuclei of smaller mass number combine to produce a nucleus of larger mass number. During a nuclear* ……Y…… *reaction a nucleus of larger mass number splits into two nuclei of smaller mass number. Both of these reactions are important because these processes can release* ……Z…… .

Which row in the table shows the missing words?

	X	*Y*	*Z*
A	fusion	fission	electrons
B	fission	fusion	energy
C	fusion	fission	protons
D	fission	fusion	protons
E	fusion	fission	energy

12. Which row in the table shows how the mass and charge of an alpha particle compares to the mass and charge of a beta particle?

	Mass of an alpha particle compared to mass of a beta particle	*Charge on an alpha particle compared to charge on a beta particle*
A	larger	same
B	larger	opposite
C	same	same
D	smaller	opposite
E	smaller	same

13. During ionisation an atom becomes a positive ion.

Which of the following has been removed from the atom?

A An alpha particle

B An electron

C A gamma ray

D A neutron

E A proton

13. A sample of tissue is exposed to 15 μGy of alpha radiation and 20 μGy of gamma radiation.

The total equivalent dose received by the tissue is

A 35 μSv

B 320 μSv

C 415 μSv

D 700 μSv

E 735 μSv.

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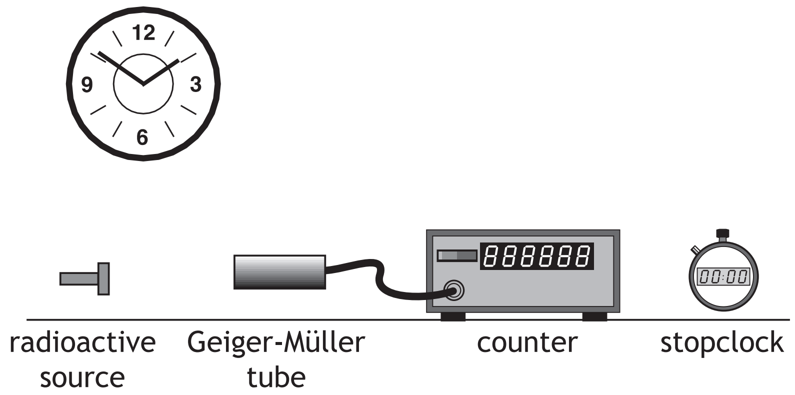
RADIATION

Practice Questions

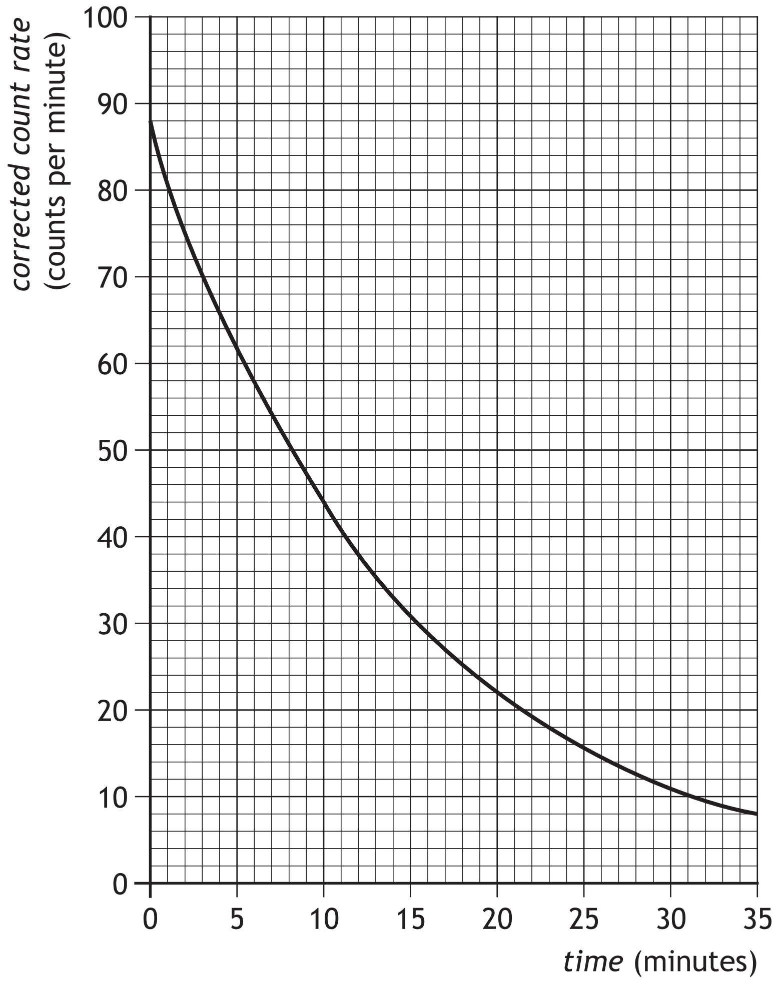
Physics
Section 2

6. A technician carries out an experiment, using the apparatus shown, to determine the half-life of a radioactive source.



(a) State what is meant by the term *half-life*. **1**

(b) The technician displays the data obtained from the experiment in the graph below.



MARKS DO NOT WRITE IN THIS MARGIN

6. (b) (continued)

(i) Describe how the apparatus could be used to obtain the experimental data required to produce this graph. **3**

(ii) Use information from the graph to determine the half-life of the radioactive source. **1**

(iii) Determine the corrected count rate after 40 minutes. **2**

Space for working and answer

Total marks 7

8. An airport worker passes suitcases through an X-ray machine.


Ints Vikamis/shutterstock.com

(a) The worker has a mass of 80·0 kg and on a particular day absorbs 7·2 mJ of energy from the X-ray machine.

(i) Calculate the absorbed dose received by the worker. **3**

Space for working and answer

(ii) Calculate the equivalent dose received by the worker. **3**

Space for working and answer

MARKS DO NOT WRITE IN THIS MARGIN

8. (continued)

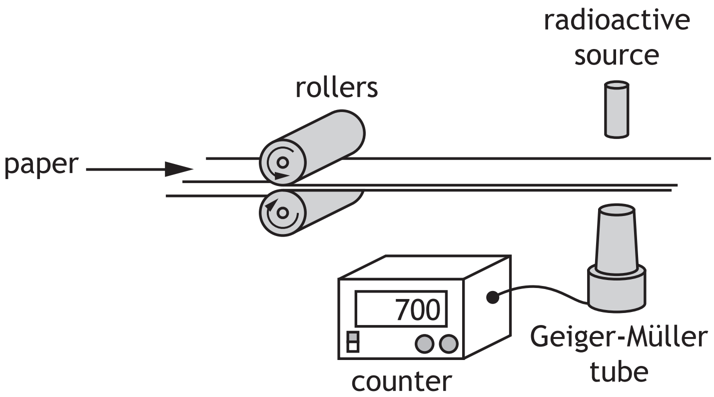
(b) X-rays can cause ionisation.

Explain what is meant by *ionisation*. **1**

Total marks 7

MARKS | DO NOT WRITE IN THIS MARGIN

6. A paper mill uses a radioactive source in a system to monitor the thickness of paper.



Radiation passing through the paper is detected by the Geiger-Müller tube. The count rate is displayed on the counter as shown. The radioactive source has a half-life that allows the system to run continuously.

(a) State what happens to the count rate if the thickness of the paper decreases. **1**

(b) The following radioactive sources are available.

Radioactive Source	*Half-life*	*Radiation emitted*
W	600 years	alpha
X	50 years	beta
Y	4 hours	beta
Z	350 years	gamma

(i) State which radioactive source should be used.

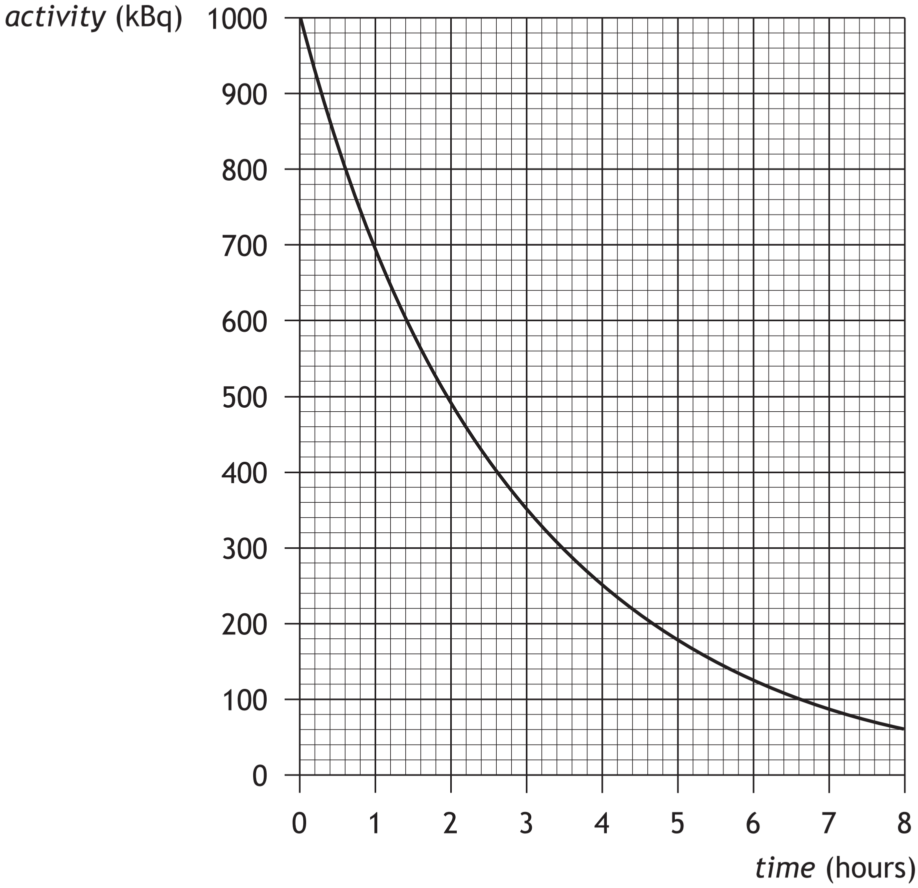
You **must** explain your answer. **3**

6. (b) (continued)

(ii) State what is meant by the term *half-life*. **1**

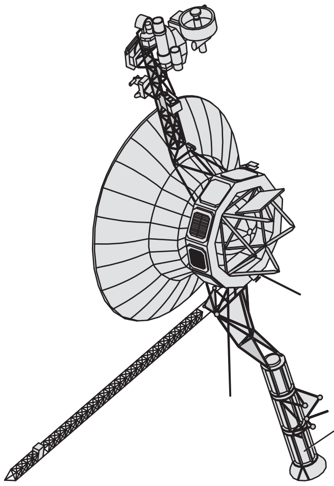
(iii) State what is meant by a gamma ray. **1**

(c) The graph below shows how the activity of another radioactive source varies with time.



Determine the half-life of this radioactive source. **1**

7. A spacecraft uses a radioisotope thermoelectric generator (RTG) as a power source.



The RTG transforms the heat released by the radioactive decay of plutonium–238 into electrical energy.

(a) In 15 minutes, $7{\cdot}92 \times 10^{18}$ nuclei of plutonium-238 decay.

Calculate the activity of the plutonium-238. **3**

Space for working and answer

(b) Each decay produces heat that is transformed into $4{\cdot}49 \times 10^{-14}$ J of electrical energy.

Determine the power output of the RTG. **2**

Space for working and answer

MARKS | DO NOT WRITE IN THIS MARGIN

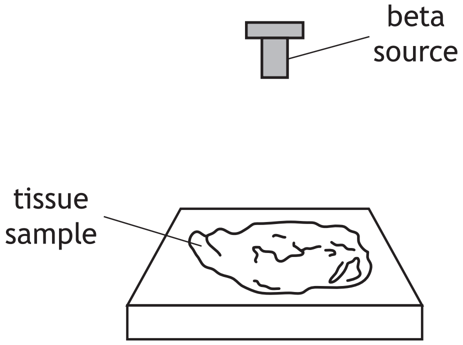
7. (continued)

(c) Plutonium-238 emits alpha radiation.

Explain why a source that emits alpha radiation requires less shielding than a source that emits gamma radiation. **1**

8. During medical testing a beta source is used to irradiate a sample of tissue of mass 0·50 kg from a distance of 0·10 m.

The sample absorbs $9{\cdot}6 \times 10^{-5}$ J of energy from the beta source.



(a) (i) Calculate the absorbed dose received by the sample. **3**

Space for working and answer

(ii) Calculate the equivalent dose received by the sample. **3**

Space for working and answer

8. (continued)

(b) The beta source used during testing has a half-life of 36 hours.

The initial activity of the beta source is 12 kBq.

Determine the activity of the source 144 hours later. **3**

Space for working and answer

5. Alpha, beta and gamma are types of nuclear radiation, which have a range of properties and effects.

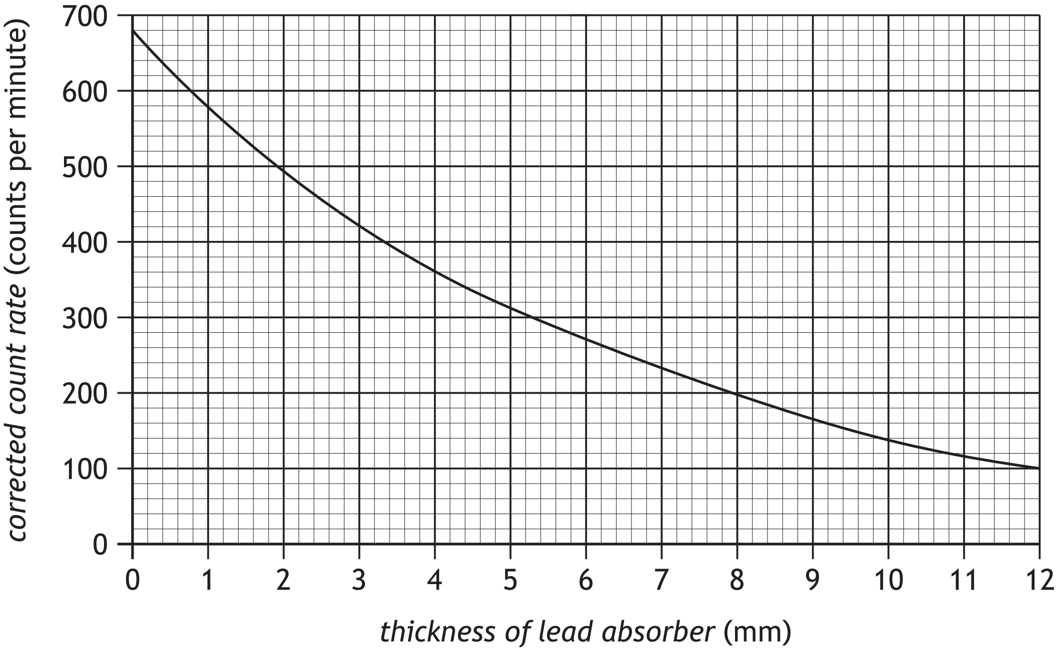
Using your knowledge of physics, comment on the similarities and/or differences between these types of nuclear radiation. **3**

6. A technician uses the apparatus shown to investigate the effect of shielding gamma radiation with lead.

Gamma radiation passing through a lead absorber is detected by a Geiger-Müller tube. The count rate is displayed on the ratemeter.

The count rates for a range of different thicknesses of lead absorber are recorded.

Using these results the technician produces a graph of corrected count rate against thickness of lead absorber as shown.



(a) State what additional measurement the technician must have made in order to determine the corrected count rate. **1**

MARKS | DO NOT WRITE IN THIS MARGIN

6. (continued)

(b) The half-value thickness of a material is the thickness of material required to reduce the corrected count rate from a source by half.

(i) Using the graph, determine the half-value thickness of lead for this source of gamma radiation. **1**

(ii) Determine the thickness of lead required to reduce the corrected count rate to one eighth of its initial value. **2**

Space for working and answer

(iii) The technician suggests repeating the experiment with aluminium absorbers instead of lead absorbers.

Predict how the half-value thickness of aluminium would compare to the half-value thickness of lead for this source. **1**

(c) When working with the radioactive source the technician is exposed to an equivalent dose rate of $2{\cdot}5 \times 10^{-6}$ Sv h^{-1}.

The annual equivalent dose limit for the technician is 20 mSv.

Calculate the maximum number of hours the technician may work with this source without exceeding this limit. **3**

Space for working and answer

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Physics
Relationships Sheet

$E_p = mgh$

$E_k = \frac{1}{2}mv^2$

$Q = It$

$V = IR$

$R_T = R_1 + R_2 + \ldots$

$\frac{1}{R_T} = \frac{1}{R_1} + \frac{1}{R_2} + \ldots$

$V_2 = \left(\frac{R_2}{R_1 + R_2}\right)V_s$

$\frac{V_1}{V_2} = \frac{R_1}{R_2}$

$P = \frac{E}{t}$

$P = IV$

$P = I^2 R$

$P = \frac{V^2}{R}$

$E_h = cm\Delta T$

$p = \frac{F}{A}$

$\frac{pV}{T} = \text{constant}$

$p_1V_1 = p_2V_2$

$\frac{p_1}{T_1} = \frac{p_2}{T_2}$

$\frac{V_1}{T_1} = \frac{V_2}{T_2}$

$d = vt$

$v = f\lambda$

$T = \frac{1}{f}$

$A = \frac{N}{t}$

$D = \frac{E}{m}$

$H = Dw_R$

$\dot{H} = \frac{H}{t}$

$s = vt$

$d = \bar{v}t$

$s = \bar{v}t$

$a = \frac{v - u}{t}$

$W = mg$

$F = ma$

$E_w = Fd$

$E_h = ml$

Additional Relationships

Circle

circumference = $2\pi r$

area = πr^2

Sphere

area = $4\pi r^2$

volume = $\frac{4}{3}\pi r^3$

Trigonometry

$$\sin\Theta = \frac{\text{opposite}}{\text{hypotenuse}}$$

$$\cos\Theta = \frac{\text{adjacent}}{\text{hypotenuse}}$$

$$\tan\Theta = \frac{\text{opposite}}{\text{adjacent}}$$

$$\sin^2\Theta + \cos^2\Theta = 1$$

Electron Arrangements of Elements

Key

Atomic number Symbol Electron arrangement Name

Transition Elements (groups 3–12)

Group 1 (1)	Group 2 (2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	Group 3 (13)	Group 4 (14)	Group 5 (15)	Group 6 (16)	Group 7 (17)	Group 0 (18)
1 **H** 1 Hydrogen																	2 **He** 2 Helium
3 **Li** 2,1 Lithium	4 **Be** 2,2 Beryllium											5 **B** 2,3 Boron	6 **C** 2,4 Carbon	7 **N** 2,5 Nitrogen	8 **O** 2,6 Oxygen	9 **F** 2,7 Fluorine	10 **Ne** 2,8 Neon
11 **Na** 2,8,1 Sodium	12 **Mg** 2,8,2 Magnesium											13 **Al** 2,8,3 Aluminium	14 **Si** 2,8,4 Silicon	15 **P** 2,8,5 Phosphorus	16 **S** 2,8,6 Sulfur	17 **Cl** 2,8,7 Chlorine	18 **Ar** 2,8,8 Argon
19 **K** 2,8,8,1 Potassium	20 **Ca** 2,8,8,2 Calcium	21 **Sc** 2,8,9,2 Scandium	22 **Ti** 2,8,10,2 Titanium	23 **V** 2,8,11,2 Vanadium	24 **Cr** 2,8,13,1 Chromium	25 **Mn** 2,8,13,2 Manganese	26 **Fe** 2,8,14,2 Iron	27 **Co** 2,8,15,2 Cobalt	28 **Ni** 2,8,16,2 Nickel	29 **Cu** 2,8,18,1 Copper	30 **Zn** 2,8,18,2 Zinc	31 **Ga** 2,8,18,3 Gallium	32 **Ge** 2,8,18,4 Germanium	33 **As** 2,8,18,5 Arsenic	34 **Se** 2,8,18,6 Selenium	35 **Br** 2,8,18,7 Bromine	36 **Kr** 2,8,18,8 Krypton
37 **Rb** 2,8,18,8,1 Rubidium	38 **Sr** 2,8,18,8,2 Strontium	39 **Y** 2,8,18,9,2 Yttrium	40 **Zr** 2,8,18, 10,2 Zirconium	41 **Nb** 2,8,18, 12,1 Niobium	42 **Mo** 2,8,18,13, 1 Molybdenum	43 **Tc** 2,8,18,13, 2 Technetium	44 **Ru** 2,8,18,15, 1 Ruthenium	45 **Rh** 2,8,18,16, 1 Rhodium	46 **Pd** 2,8,18, 18,0 Palladium	47 **Ag** 2,8,18, 18,1 Silver	48 **Cd** 2,8,18, 18,2 Cadmium	49 **In** 2,8,18, 18,3 Indium	50 **Sn** 2,8,18, 18,4 Tin	51 **Sb** 2,8,18, 18,5 Antimony	52 **Te** 2,8,18, 18,6 Tellurium	53 **I** 2,8,18, 18,7 Iodine	54 **Xe** 2,8,18, 18,8 Xenon
55 **Cs** 2,8,18,18, 8,1 Caesium	56 **Ba** 2,8,18,18, 8,2 Barium	57 **La** 2,8,18,18, 9,2 Lanthanum	72 **Hf** 2,8,18,32, 10,2 Hafnium	73 **Ta** 2,8,18, 32,11,2 Tantalum	74 **W** 2,8,18,32, 12,2 Tungsten	75 **Re** 2,8,18,32, 13,2 Rhenium	76 **Os** 2,8,18,32, 14,2 Osmium	77 **Ir** 2,8,18,32, 15,2 Iridium	78 **Pt** 2,8,18,32, 17,1 Platinum	79 **Au** 2,8,18, 32,18,1 Gold	80 **Hg** 2,8,18, 32,18,2 Mercury	81 **Tl** 2,8,18, 32,18,3 Thallium	82 **Pb** 2,8,18, 32,18,4 Lead	83 **Bi** 2,8,18, 32,18,5 Bismuth	84 **Po** 2,8,18, 32,18,6 Polonium	85 **At** 2,8,18, 32,18,7 Astatine	86 **Rn** 2,8,18, 32,18,8 Radon
87 **Fr** 2,8,18,32, 18,8,1 Francium	88 **Ra** 2,8,18,32, 18,8,2 Radium	89 **Ac** 2,8,18,32, 18,9,2 Actinium	104 **Rf** 2,8,18,32, 32,10,2 Rutherfordium	105 **Db** 2,8,18,32, 32,11,2 Dubnium	106 **Sg** 2,8,18,32, 32,12,2 Seaborgium	107 **Bh** 2,8,18,32, 32,13,2 Bohrium	108 **Hs** 2,8,18,32, 32,14,2 Hassium	109 **Mt** 2,8,18,32, 32,15,2 Meitnerium	110 **Ds** 2,8,18,32, 32,17,1 Darmstadtium	111 **Rg** 2,8,18,32, 32,18,1 Roentgenium	112 **Cn** 2,8,18,32, 32,18,2 Copernicium						

Lanthanides	57 **La** 2,8,18, 18,9,2 Lanthanum	58 **Ce** 2,8,18, 20,8,2 Cerium	59 **Pr** 2,8,18,21, 8,2 Praseodymium	60 **Nd** 2,8,18,22, 8,2 Neodymium	61 **Pm** 2,8,18,23, 8,2 Promethium	62 **Sm** 2,8,18,24, 8,2 Samarium	63 **Eu** 2,8,18,25, 8,2 Europium	64 **Gd** 2,8,18,25, 9,2 Gadolinium	65 **Tb** 2,8,18,27, 8,2 Terbium	66 **Dy** 2,8,18,28, 8,2 Dysprosium	67 **Ho** 2,8,18,29, 8,2 Holmium	68 **Er** 2,8,18,30, 8,2 Erbium	69 **Tm** 2,8,18,31, 8,2 Thulium	70 **Yb** 2,8,18,32, 8,2 Ytterbium	71 **Lu** 2,8,18,32, 9,2 Lutetium
Actinides	89 **Ac** 2,8,18,32, 18,9,2 Actinium	90 **Th** 2,8,18,32, 18,10,2 Thorium	91 **Pa** 2,8,18,32, 20,9,2 Protactinium	92 **U** 2,8,18,32, 21,9,2 Uranium	93 **Np** 2,8,18,32, 22,9,2 Neptunium	94 **Pu** 2,8,18,32, 24,8,2 Plutonium	95 **Am** 2,8,18,32, 25,8,2 Americium	96 **Cm** 2,8,18,32, 25,9,2 Curium	97 **Bk** 2,8,18,32, 27,8,2 Berkelium	98 **Cf** 2,8,18,32, 28,8,2 Californium	99 **Es** 2,8,18,32, 29,8,2 Einsteinium	100 **Fm** 2,8,18,32, 30,8,2 Fermium	101 **Md** 2,8,18,32, 31,8,2 Mendelevium	102 **No** 2,8,18,32, 32,8,2 Nobelium	103 **Lr** 2,8,18,32, 32,9,2 Lawrencium