GCSE

Combined Sciences: Physics

For years 10 and 11

CORE KNOWLEDGE

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Don't just calculate…

HEIST

Highlight – Identify what any number with units is measuring and show them being converted to standard units.

Equation – Write out the equation (as words or symbols) that includes the measurements that you have and the one that you want.

Insert values – Rewrite the equation with the numbers in the place of the words or symbols

Solve – Rearrange the equation by doing the same operation to both sides of the equals sign so all of the numbers end up on one side.

Top it off – Round your answer to a sensible number of **significant figures** and write the correct **unit** at the end.

Example

acceleration

initial velocity

A spaceship is travelling at 5 m/s before it turns on engines that provide a constant acceleration of $0.01\ m/s^2$. How fast is it travelling after three minutes?

final velocity?

time

3 minutes × 60 = 180 s

$a = (v - u) \div t$

$0.01 = (v - 5) \div 180$

[×180] [×180]

$0.01 \times 180 = v - 5$

[+5] [+ 5]

$1.8 + 5 = v$

$v = 6.8\ m/s$

↓ How to convert values in to standard units

Metric prefixes

converting: bigger to smaller each step is × 1000; smaller to bigger each step is ÷ 1000

prefix	abbreviation
tera-	T
giga-	G
mega-	M
kilo-	k
Standard unit	-------
milli-	m
micro-	µ
nano-	n
pico-	p

Time

bigger to smaller each x; smaller to bigger each step is ÷

what to × or ÷ by		symbol
	weeks	wk
7		
	days	d
24		
	hours	hr
60		
	minutes	min
60		
	seconds	s
1000		
	milliseconds	ms

Top Tip:

'significant figures' (sometimes shortened to s.f.) is a count of any non-zero numbers at the start of a value. Look carefully at your number to see if you need to round up or round down.

1245 m/s to two s.f. is 1200 m/s

1254 m/s to two s.f. is 1300 m/s

0.0124539 m to 3 s.f. is 0.0125 m

Top Tip:

Unless you are told otherwise, round long answers to three significant figures.

HT = higher tier

	distance travelled = average speed × time	
	acceleration = change in velocity ÷ time taken	$a = \frac{(v-u)}{t}$
	force = mass × acceleration	$F = m \times a$
	weight = mass × gravitational field strength	$W = m \times g$
HT	**momentum = mass × velocity**	$\boldsymbol{p = m \times v}$
	change in gravitational potential energy = mass × gravitational field strength × change in vertical height	$\Delta GPE = m \times g \times \Delta h$
	kinetic energy = 1/2 × mass × (speed)^2	$KE = \frac{1}{2} \times m \times v^2$
	efficiency = $\frac{(\text{useful energy transferred by the device})}{(\text{total energy supplied to the device})}$	
	wave speed = frequency × wavelength	$v = f \times \lambda$
	wave speed = distance ÷ time	$v = \frac{x}{t}$
	work done = force × distance moved in the direction of the force	$E = F \times d$
	power = work done ÷ time taken	$P = \frac{E}{t}$
	energy transferred = charge moved × potential difference	$E = Q \times V$
	charge = current × time	$Q = I \times t$
	potential difference = current × resistance	$V = I \times R$
	power = energy transferred ÷ time taken	$P = \frac{E}{t}$
	electrical power = current × potential difference	$P = I \times V$
	electrical power = (current)^2 × resistance	$P = I^2 \times R$
	density = mass ÷ volume	$\rho = \frac{m}{V}$

	force exerted on a spring = spring constant × extension	$F = k \times x$
	(final velocity)^2 – (initial velocity)^2 = 2 × acceleration × distance	$v^2 - u^2 = 2 \times a \times x$
HT	**force = change in momentum ÷ time**	$\boldsymbol{F = \frac{(mv - mu)}{t}}$
	energy transferred = current × potential difference × time	$E = I \times V \times t$
HT	**force on a conductor at right angles to a magnetic field carrying a current = magnetic flux density × current × length**	$\boldsymbol{F = B \times I \times l}$
	For transformers with 100% efficiency, potential difference across primary coil × current in primary coil = potential difference across secondary coil × current in secondary coil	$V_P \times I_P = V_S \times I_S$
	change in thermal energy = mass × specific heat capacity × change in temperature	$\Delta Q = m \times c \times \Delta\theta$
	thermal energy for a change of state = mass × specific latent heat	$Q = m \times L$
	energy transferred in stretching = 0.5 × spring constant × (extension)^2	$E = \frac{1}{2} \times k \times x^2$

If you're taking **GCSE (9–1) Physics**, you also need these extra equations:

	moment of a force = force × distance normal to the direction of the force	
	pressure = force normal to surface ÷ area of surface	$P = \frac{F}{A}$
HT	$\frac{\textit{potential difference across primary coil}}{\textit{potential difference across secondary coil}} = \frac{\textit{number of turns in primary coil}}{\textit{number of turns in secondary coil}}$	$\boldsymbol{\frac{V_P}{V_S} = \frac{N_P}{N_S}}$
	to calculate pressure or volume for gases of fixed mass at constant temperature	$P_1 \times V_1 = P_2 \times V_2$
HT	**pressure due to a column of liquid = height of column × density of liquid × gravitational field strength**	$\boldsymbol{P = h \times \rho \times g}$

END OF EQUATION LIST

Standard Units

Standard Unit	Physical value it measures
m (metres)	**distance** or **length** *equation symbol* d *or* displacement, *x* wavelength, λ change in height, Δh
s (seconds)	**time** *equation symbol* t
m/s (metres per second)	**velocity** or **speed** *equation symbol v, u or s* *or* wave speed
m/s^2 (metres per second squared)	**acceleration** *equation symbol* a or acceleration due to gravity, *g*
N (Newtons)	**force** *equation symbol* F *or* weight, W
N/kg (Newtons per kilogram)	**gravitational field strength** *equation symbol* g
kgm/s (kilogram metres per second)	**momentum** *equation symbol* p
J (Joules)	**energy** *equation symbol* E *or* work done, E
Hz (Hertz)	**frequency** *equation symbol* f
A (Amps or Amperes)	**current** *equation symbol* I

Standard Unit	Physical value it measures
C (Coulombs)	**charge** *equation symbol* Q
V (Volts)	**potential difference** *equation symbol* V *or* supply voltage, V
Ω (Ohms)	**resistance** *equation symbol* R
J/kg°C (Joules per kilogram degrees centigrade)	**specific heat capacity** *equation symbol* c
J/kg (Joules per kilogram)	**latent heat** (of fusion or of vaporisation) *equation symbol* L
kg/m^3 (kilograms per metres cubed)	**density** *equation symbol* ρ
W (Watts)	**power** *equation symbol* P
T (Teslas)	**magnetic flux density** *equation symbol* B
N/m (Newtons per metre)	**spring constant** *equation symbol* k

Essential Knowledge

Topic 0: Working Scientifically and Topic 1: Key Concepts in Physics

1	What does 'give your answer to two significant figures' mean?	Round the final answer up or down so that you are only writing down two numerals, ignoring any zeros that come at the front. (e.g. 20, 37 and 0.0054)
2	What does 'give your answer to an appropriate number of significant figures' mean?	Round the final answer up or down so that you are writing down the same number of numerals as the value used in your calculation that had the fewest numerals. (e.g. 30.77 ÷ 12 = 2.6 because '12' was written to two significant figures.)
3	What does 'give your answer to two decimal places' mean?	Round the final answer up or down so that there are exactly two numerals written after the decimal point. (e.g. 20.22, 37.00 and 0.01)
4	Put these prefixes for values smaller than 1 in order from largest to smallest: micro (μ), milli (m), nano (n)	milli (m) is 1000x bigger than micro (μ) which is 1000x bigger than nano (n)

5	Put these prefixes for values larger than 1 in order from smallest to largest: kilo (k), giga (G), mega (M), tera (T).	kilo (k) is 1000x smaller than mega (M) which is 1000x smaller than giga (G) which is 1000x smaller than tera (T)
6	State the phrase that describes the relationship between two variables if they make a straight line on a graph when plotted against each other.	Directly proportional *accept* They have a doubling relationship
7	State the name given to the variable in an investigation that is changed or allowed to change so that its effect on another variable can be investigated.	the independent variable
8	State the name given to the variable in an investigation that is measured to see if it is affected by changes in another variable.	the Dependent variable
9	State the name given to the variables in an investigation that are kept the same each time to make sure that they could not be causing any changes in the results.	Control variables

Topic 2.1: Motion and Forces part 1

10	State the equation that shows the relationship between distance, time and speed.	s = d ÷ t or speed = distance ÷ time
11	Which measurement has the standard unit m?	distance *accept* d *accept* displacement *or x, accept* wavelength *or* λ, *accept* change in height or Δh
12	Which measurement has the standard unit s?	time *accept* t
13	Which measurement has the standard unit m/s?	velocity *accept v or u* *accept speed or s* *accept* waves peed
14	How many seconds (s) are in one minute (min)?	60 seconds per minute
15	How many minutes (s) are in one hour (h)?	60 minutes per hour
16	How many metres (m) are in one kilometre (km)?	1000 metres per kilometre *accept* 1×10^3
17	What is a typical speed for a walking person?	1.4 m/s (on average)
18	What is a typical speed for a cyclist?	6 m/s (on average)
19	What is a typical speed for a car in a built up area (such as outside a school)?	10.5 m/s (on average)
20	What is a typical speed for a car on a motorway?	31 m/s (on average)
21	How is a vector quantity different from a scalar quantity?	vectors include direction as well as magnitude (scalar only has magnitude)
22	What does 'magnitude' mean?	How big something is.
23	How is displacement different from distance?	Displacement is a measure of the straight-line distance from a start point and end point. Displacement is a vector (it includes direction and can be negative)
24	How is velocity different from distance?	Velocity is a measure of speed relative to a stated direction. Velocity is a vector (it includes direction and can be negative)
25	Which measurement has the standard unit m/s^2?	Acceleration *accept* a

26	State the equation that shows the relationship between changes in velocity, time, and acceleration.	**a = (v - u) ÷ t** *or* (final velocity - initial velocity) ÷ time *or* change in velocity ÷ time
27	Which measurement has the standard unit N?	**Force** *accept* F *also accept* weight *or* W
28	What does 'resultant force' mean?	A single force that describes the outcome of multiple forces acting on an object. (e.g. 200 N acting left and 150 N acting right would mean a resultant force of 50 N acting left)
29	How must the forces acting on an object compare to cause an object to be not accelerating/moving at constant velocity.	(forces must be) balanced. *or* resultant force must be zero.
30	How must the forces acting on an object compare to cause an object to be accelerating/changing velocity.	(forces must be) unbalanced. *or* resultant force must be larger than zero.
31	What does Newton's first law of motion state	The velocity of an object will only change if there is a resultant force acting on it.
32	State the equation that shows the relationship between gravitational field strength, mass and weight.	W = m x g or weight = mass x gravitational field strength *accept* 'gravity' in place of gravitational field strength
33	State the standard unit for weight.	N or Newtons
34	Which measurement has the standard unit N/kg?	Gravitational field strength *accept* g
35	State the value for gravitational field strength at the surface of the Earth.	10 N/kg or m/s^2
36	How many grams (g) are in one kilogram (kg)?	1000 grams per kilogram *accept* 1×10^3
37	State the equation that shows the relationship between mass, force and acceleration.	F = m × a Force (N) = mass (kg) x acceleration (m/s^2)
38	What does Newton's second law of motion state?	The acceleration of an object increases if the resultant force on it increases, and decreases if the mass of the object increases. *accept* F = m × a *accept* F = (mv - mu) ÷ t
39	In what situation would a scientist use a computerised method, such as a light gate, to measure time rather than a stopwatch?	If the time being measured was close to or smaller than human reaction time (roughly 0.25 s)
40	In an investigation involving a trolley moving down a ramp, what is the most likely reason for tilting the ramp?	To compensate for friction. *accept* So that weight balances friction. *DO NOT ACCEPT* to get rid of friction.
41	In an investigation involving a trolley being pulled down a ramp by hanging masses, what is the most likely reason for masses being moved from the hook to the trolley (or vice versa)?	To keep the total mass of the system constant (while changing the force pulling the trolley)
42	What does Newton's third law of motion state?	Any two objects interacting will exert forces on each other that are equal in size but opposite in direction.
43	State the equation that shows the relationship between mass, momentum and velocity.	p = m x v momentum (kgm/s) = mass (kg) x velocity (m/s)
44	Which measurement has the standard unit kgm/s?	Momentum *accept* p

45	What does the law of conservation of momentum state?	The total momentum of all objects in a collision added together before the collision is equal to the total momentum of all objects added together after the collision.
46	State the equation that shows the relationship between force, time and change in momentum.	F = (mv - mu) ÷ t or F = (m(v - u)) ÷ t Force (N) = change in momentum (kgm/s) ÷ time (s)

Topic 2.2: Motion and Forces part 2

47	Describe the motion of an object when a distance-time graph is a straight line.	Constant velocity *accept* not accelerating
48	Describe the motion of an object when a distance-time graph is a flat horizontal line.	Stationary *accept* constant velocity of 0 m/s
49	Describe the motion of an object when a distance-time graph is a curved line.	Changing velocity *accept* accelerating
50	Describe how to calculate the gradient of a straight line on a graph.	• Mark two points anywhere on the line. • Find the values on the Y (vertical axis) and X (horizontal axis) that line up with each point. • Calculate difference between Y values of the first and second points. • Calculate difference between X values of the first and second points. • Gradient = change in Y values ÷ change in X values. *accept* gradient = $\Delta y \div \Delta x$
51	Describe how to calculate the velocity of an object from its distance-time graph.	Calculate the gradient (of the line)
52	Describe the motion of an object when a velocity-time graph is a straight line.	Changing velocity *accept* accelerating
53	Describe the motion of an object when a distance-time graph is a flat horizontal line.	Constant velocity *accept* not accelerating
54	Describe how to calculate the acceleration of an object from its velocity-time graph.	Calculate the gradient (of the line)
55	Describe how to calculate the distance travelled by an object from its velocity-time graph.	Calculate the area under the graph
56	Describe how air bags, seat belts, crumple zones, cycle helmets, crash mats in gyms and rubber floors in playgrounds reduce the forces acting on people during accidents.	(they all) increase the time taken for a change in momentum *accept* F = (mv - mu) ÷ t with bigger t
57	State the equation that shows the relationship between stopping distance, thinking distance and braking distance.	Stopping distance (m) = Thinking distance (m) + Braking distance (m)
58	Name at least three factors that affect the thinking distance for a car performing an emergency stop.	(any three from...) • Velocity/speed of the car • Alcohol/drugs • Tiredness • Distractions • Illness *accept* reaction time (of driver)
59	Name at least three factors that affect the braking distance for a car performing an emergency stop.	(any three from...) • Velocity/speed of the car • Mass of the car • Condition of car's brakes • Condition of the road *accept* Weather conditions but *DO NOT ACCEPT* fog

60	When an object moves in a circle why is it true to say that it is accelerating even if its speed is constant?	Direction is changing, so **velocity** is changing and change in velocity over time is acceleration.
61	When an object moves in a circle there is a force acting towards the centre of the circle. What is the name given to this force?	Centripetal force
62	State the equation that shows the relationship between distance, acceleration, initial velocity and final velocity.	$v^2 - u^2 = 2 \times a \times x$ *accept* final velocity squared (m/s) - initial velocity squared (m/s) = 2 × acceleration (m/s^2) × distance (m)

Topic 3: Conservation of Energy

63	Name at least three forms of *stored* energy	(Any three from...) Kinetic energy (or KE), heat (or thermal or internal), gravitational potential energy (or GPE), chemical, elastic potential, nuclear. *Also accept* magnetic or electrostatic
64	Name at least two pathways through which energy can be transferred	(Any two from...) • **Mechanical**/by contact forces causing objects to move • **Radiation**/by waves (such as light or infrared (thermal) radiation) • **Electrical**/by electrical current (when there is a potential difference) • **Heating**/by particles moving (including conduction or the results of chemical reactions or electrical currents)
65	Which measurement has the standard unit J?	Energy *accept* E *accept* any named form of energy *accept* work done
66	How many Joules (J) are in one kilojoule (kJ)?	1000 joules per kilojoule *accept* 1×10^3
67	How many Joules (J) are in one megajoule (MJ)?	1 000 000 joules per megajoule *accept* 1×10^6
68	How many Joules (J) are in one gigajoule (GJ)?	1 000 000 000 joules per gigajoule *accept* 1×10^9
69	What does the law of conservation of energy state?	The total energy before an energy transfer is equal to the total energy after. *accept* Total input energy = Total output energies *accept* Energy cannot be created or destroyed
70	Describe the shift between energy stores that happens when an object is is falling towards the Earth.	GPE → KE *or* gravitational potential energy is transferred to a store of kinetic energy *ignore* kinetic energy stored in the object is shifted to a store of thermal energy in the air particles they collide with.
71	Describe the shift between energy stores that happens when fuel is burning.	Chemical → thermal *or* chemical energy is transferred to a store of thermal energy in the fuel and the surroundings *ignore* thermal energy is dissipated to the surroundings
72	Describe the shift between energy stores that happens when a spring is being stretched.	KE → Elastic potential *or* kinetic energy is transferred to a store of elastic potential energy *ignore* kinetic energy stored is shifted to a store of thermal energy in the spring
73	Describe the shift between energy stores that happens when a car's brakes are activated.	KE → Thermal *or* Kinetic energy stored in the moving car is transferred to a store of thermal energy in the brake disks/pads/brakes *ignore* thermal energy is dissipated to the surroundings

74	Describe the shift between energy stores that happens when a moving object collides with an obstacle.	KE → Thermal (+ sound) *or* Kinetic energy stored in the moving object is transferred to a store of thermal energy in the faster moving particles of the object and obstacle *ignore* thermal energy is dissipated to the surroundings
75	What word, often used to describe thermal energy transfers, means 'spread out into the surroundings'?	dissipated
76	State the equation that shows the relationship between efficiency, total energy supplied to a device and useful energy transferred by the device.	Efficiency = useful ÷ total input
77	Suggest how unwanted energy transfers can be reduced in a device that has lots of moving parts.	Apply oil/lubrication (to reduce friction)
78	State the three ways by which thermal energy transfers.	• Conduction (particles colliding with their neighbours); • Convection (pockets of less dense particles in a fluid floating upwards); • Radiation (as infra-red waves)
79	Describe what affects how quickly thermal energy transfers through the walls of a house.	• Thickness (of the walls) • (thermal conductivity of) The material the walls are made of *accept* Whether there is an air gap/cavity wall/insulation inside the wall *accept* Temperature difference between each side of the wall
80	State the equation that shows the relationship between gravitational potential energy/GPE, mass, height and gravitational field strength.	$\Delta GPE = m \times g \times \Delta h$ *or* (change in) gravitational potential energy (J) = mass (kg) x gravitational field strength (N/kg) x change in height (m)
81	State the equation that shows the relationship between kinetic energy, mass and velocity.	$KE = \frac{1}{2} \times m \times v^2$ *or* Kinetic energy (J) = 0.5 x mass (kg) x velocity squared (m/s)
82	State at least two non-renewable energy sources	(Any two from...) • Oil • Natural gas • Coal • Nuclear fuel (*accept* nuclear fission *or* nuclear fusion) *accept* Fossil fuels
83	State at least three renewable energy sources	(Any three from...) • Solar power • Wind (turbines) • Biofuel • Hydroelectricity • Geothermal • Tidal power

Topic 4: Waves

84	Which of the following can waves transfer? Energy, Matter, Information.	Energy and information
85	Describe how to tell that a wave is a longitudinal wave (as opposed to a transverse wave)	(in a longitudinal wave) **oscillations are in the same direction** as the wave's travel *accept* parallel to the wave's travel *accept* vibrations for oscillations
86	Describe how to tell that a wave is a transvers wave (as opposed to a longitudinal wave)	(in a transverse wave) **oscillations are perpendicular** to the wave's travel *accept* 'at right angles' to the wave's travel *accept* vibrations for oscillations

87	Name an example of a longitudinal wave	**sound** or **seismic P-waves**
88	What is a typical speed for a sound wave in air?	330 m/s (in air)
89	Name at least two examples of transverse waves	**water** **any electromagnetic wave** (gamma, xray, ultraviolet, (visible) light, infrared, microwave, radio waves) **Seismic S-waves**
90	What does 'wavelength (of a wave)' mean?	The distance over which the shape of a wave repeats. *accept* the distance between two idental parts of a wave. *accept* peak to peak or trough to trough.
91	What does 'amplitude (of a wave)' mean?	The maximum distance between the top or bottom of a wave and the rest position. *accept* half the distance from peak to trough. *do NOT accept* the height of the wave.
92	What does 'frequency (of a wave)' mean?	The number of waves passing a point each second. *accept* waves per second.
93	What does 'period (of a wave)' mean?	The time it takes for one complete wave to pass a point.
94	Which measurement has the standard unit Hz?	Frequency *accept* f
95	State the equation that shows the relationship between wavespeed, distance and time.	$v = x \div t$ wavespeed (m/s) = distance (m) ÷ time (s)
96	State the equation that shows the relationship between wavespeed, frequency and wavelength.	$v = f \times \lambda$ wavespeed (m/s) = frequency (Hz) x wavelength (m)
97	Describe how to determine the frequency of a water wave.	Start timing. Count the number of waves passing a fixed point. Stop timing and counting at the same time. Divide number of waves counted by time taken.
98	State the name of the phenomenon of waves changing direction when they travel from one medium to another	Refraction
99	State the name given to a wave travelling into the boundary between two different media (e.g. a light ray going from air into a glass block)	the Incident Ray
100	State the name given to a line that is drawn at right angles to the boundary between the two different media, used for measuring angles against.	the Normal Line
101	State the name given to the angle between a wave travelling into a boundary between two media and the line at right angles to the boundary?	the Angle of Incidence
102	State the name given to the angle between a wave after it has crossed a boundary between two media and the line at right angles to the boundary?	the Angle of Refraction
103	State the name given to a wave that has travelled across the boundary between two different media (e.g. a light ray that has gone from air and is now in a glass block)	the Refracted Ray
104	Describe the change in direction for a wave travelling into a medium that it travels more slowly in.	(the wave is) refracted towards the normal line.

105	Describe the change in direction for a wave travelling into a medium that it travels more quickly in.	(the wave is) refracted away from the normal line.

Topic 5: Light and the EM Spectrum

106	State the speed of any electromagnetic wave in a vacuum?	3.0×10^8 m/s *accept* 300 000 000 m/s *or* 300 000 km/s
107	Why might different electromagnetic waves interact differently with the same object?	(the waves have) different wavelengths *accept* the object absorbs/transmits/refracts/reflects different wavelengths
108	State the seven colours in the spectrum of visible light in order from longest wavelength (lowest frequency) to shortest wavelength (highest frequency).	Red, Orange, Yellow, Green, Blue, Indigo, Violet
109	State the seven types of electromagnetic waves in order from longest wavelength (lowest frequency) to shortest wavelength (highest frequency).	Radio waves; Microwavs; Infra-red (*accept* IR); Visible light; Ultraviolet (*accept* UV); X-rays; Gamma rays.
110	Name at least two types of EM waves that are forms of ionising radiation.	(any two from) Ultraviolet (*accept* UV); X-rays; Gamma rays
111	State a use for radio waves.	(long-range) communication (e.g. TV and radio broadcasts)
112	State a use for microwaves.	Communication (e.g. mobile phones, WiFi, satellites) Cooking (by heating water and fat molecules)
113	State a use for infrared radiation.	Cooking (e.g. toasters) Heating (e.g. electrical heaters) (short-range) communication (e.g. TV remote control) Night-vision cameras Security sensors
114	State a use for visible light.	Photography. Vision. Fibre optics (e.g. medical procedures like endoscopy)
115	State a use for ultraviolet light.	Security marking (e.g. detecting forged bank notes) Sterilising (e.g. disinfecting water)
116	State a use for x-rays.	Medical imaging (e.g. X-ray machine to look for broken bones in 2D, CAT scan to make a 3D image of inside the body) Security scanners (e.g. airport luggage scans) Checking internal structures of materials (e.g. checking condition of metal rebar inside concrete)
117	State a use for gamma rays.	Treating cancer (e.g. radiotherapy) Sterilising (e.g. killing bacteria on food and medical equipment) Medical imaging (e.g. PET scan to make a 3D image of inside the body). Checking internal features of materials (e.g. identifying different density liquids inside sealed columns)
118	State how radio waves are produced.	Oscillations (of electrons) in electrical circuits.
119	State how x-rays are produced.	(X-rays are emitted) When electrons suddenly lose energy (by dropping down an energy level inside an atom or suddenly slowing down after being fired at other atoms)
120	State how gamma rays are produced.	Nuclei of (radioactive) atoms undergo changes and gamma waves are released at the same time.

121	Describe the danger to humans from radio waves.	None
122	Describe the danger to humans from microwaves.	(internal) heating of body cells
123	Describe the danger to humans from infrared radiation.	Burns (to skin)
124	Describe the danger to humans from visible light.	Blindness (caused by damage to retina in the eye)
125	Describe the danger to humans from ultraviolet light.	Skin cancer Eye damage *accept* Damages living cells because UV is ionising.
126	Describe the danger to humans from x-rays.	Cancer (caused by mutation of DNA) *accept* Damages living cells because X-rays are ionising.
127	Describe the danger to humans from gamma rays.	Cancer (caused by mutation of DNA) *accept* Damages living cells because gamma rays are ionising.

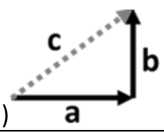
Topic 6: Radioactivity

128	To the nearest fraction of a metre, roughly what size is a typical atom?	1 x 10^{-10} m *accept* 0.000 000 0001 m *accept* 0.1 nm
129	Describe Dalton's model of the atom.	Tiny hard spheres (that are indestructible)
130	Describe JJ Thompson's model of the atom.	('plum pudding') a spherical cloud of positive charge with negative electrons embedded inside.
131	Describe how Rutherford determined the nuclear model of the atom.	• Tiny positive (alpha) particles were fired at thin gold foil • Most particles were detected passing straight through • Small number of particles (~1/8000) were scattered/deflected (some even reflected) (so most of an atom must be empty space with a small, positive core - the nucleus)
132	Describe the basic structure of an atom as we understand it today	**Nucleus** containing positive **protons** and neutral **neutrons.** Negative **electrons** orbiting outside in **energy levels** *accept* orbitals or shells for energy levels
133	Describe how to use the atomic number and mass number of an atom to calculate the number of neutrons in its nucleus.	neutrons = mass number - atomic number *accept* difference between the numbers
134	What is being defined here: 'Atoms with the same number of protons but different numbers of neutrons'	Isotopes
135	Describe what happens within an atom when it absorbs electromagnetic radiation.	Electron moves up to a **higher energy level** (further from the nucleus)
136	Describe what happens within an atom to cause it to emit electromagnetic radiation	Electron moves down to a **lower energy level** (closer to the nucleus)
137	What is being defined here: 'The process of an atom gaining or losing an electron or electrons'	Ionisation
138	Name at least two natural sources of background radiation.	Cosmic rays, rocks in the ground, radon gas, food
139	Name a man-made source of background radiation.	nuclear power, medical procedures, nuclear weapons
140	Name the device that connects to a counter to detect ionising radiation.	Geiger-Müller tube *accept* GM-tube
141	Name a way of detecting ionising radiation that doesn't require a power source.	photographic film *or* dosimeter
142	Which measurement has the standard unit Bq (Bequerel)?	Radioactivity of a radioactive source *accept* number of nuclear decays per second

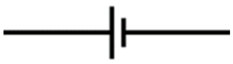
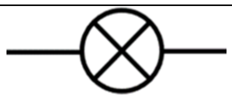
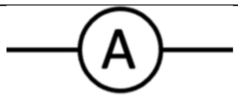
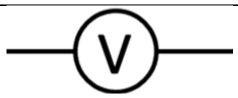
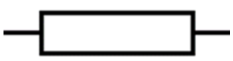
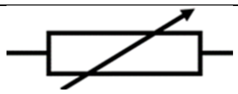
143	Describe how a scientist should use a GM-tube to record an accurate count for the radioactivity of a sample.	• record **background radiation** without sample present • Hold sample in front of GM-tube and record count again • Take background count away from sample count
144	Explain why nuclear radiation is dangerous to living things	It **damages living cells** (causing mutation/cancer) because it is **ionising.** *accept* high doses can cause burns/radiation sickness/death
145	What is being defined here: 'Exposing an object or person to radiation'	Irradiation
146	What is being defined here: '(unwanted) radioactive particles getting onto/into an object'	contamination
147	Why are some isotopes radioactive when others aren't?	(Radioactive isotopes) have an **unstable nucleus** (that can become stable by undergoing radioactive decay/emitting radiation)
148	Why is it impossible to predict when a specific radioactive nucleus will decay?	Radioactive decay is **random**
149	Describe at least two safety precautions taken by people working with radioactive material.	• limit exposure time • use lowest effective dose • monitor exposure (with dosimeter badges) • shielding (such as lead-lined containers) • wear protective clothing (such as disposable gloves)
150	What is being defined here: 'The time it takes for half of the undecayed nuclei in a radioactive material to decay.'	half life
151	Describe what happens to particles inside of an atom during alpha decay.	Two protons and two neutrons are ejected from the nucleus.
152	Describe what happens to particles inside of an atom during beta minus decay.	A neutron becomes a proton. A high-energy electron is ejected from the nucleus.
153	Describe what happens to particles inside of an atom during beta plus decay.	A proton becomes a neutron. A high-energy positron is ejected from the nucleus.
154	What form of radiation does this nuclear equation show? $^{A}_{Z}X \rightarrow\ ^{A-4}_{Z-2}Y +\ ^{4}_{2}\alpha$	Alpha radiation *accept* a helium nucleus
155	What form of radiation does this nuclear equation show? $^{A}_{Z}X \rightarrow\ _{Z+1}^{\ \ A}Y +\ _{-1}^{\ \ 0}e$	Beta minus radiation *accept* a high energy electron
156	What form of radiation does this nuclear equation show? $^{A}_{Z}X \rightarrow\ _{Z-1}^{\ \ A}Y +\ _{+1}^{\ \ 0}e$	Beta plus radiation *accept* a positron
157	What form of radiation does this nuclear equation show? $^{A}_{Z}X \rightarrow\ ^{A}_{Z}Y +\ ^{0}_{0}\gamma$	Gamma radiation *accept* a high frequency electromagnetic wave
158	What form of radiation does this nuclear equation show? $^{A}_{Z}X \rightarrow\ ^{A-1}_{\ \ Z}Y +\ ^{1}_{0}n$	Neutron radiation

159	Put these types of nuclear radiation in order from most to least penetrating: alpha, beta, gamma	(most penetrating first) **gamma > beta > alpha**.
160	Put these types of nuclear radiation in order from most to least ionising: alpha, beta, gamma	(most ionising first) **alpha > beta > gamma**

Topics 8 and 9: Energy – Forces doing Work and Forces and their Effects

161	State the equation that shows the relationship between work done, force and distance moved in the direction of the force.	**$E = F \times d$** *accept* work done (J) = force (N) x distance moved in the direction of the force (m)
162	Describe the relationship between work done by a force acting on an object and energy transferred.	They are the same
163	What is being defined here: 'The rate at which energy is being transferred'?	power *accept* P
164	Describe some ways that objects might interact at a distance without contact.	(Through interactions of fields such as...) **gravitational** attraction; **electrostatic** attraction/repulsion; **magnetic** attraction/repulsion *accept* positive and negatives for electrostatic. *accept* north and south poles for magnetic.
165	Describe how to calculate the resultant force of two forces acting at right angles to each other.	Draw a scale diagram of the forces end-to-end. Draw a line to join the start and end points so that a triangle is formed. Use Pythagoras' theorem to calculate length of hypotenuse.  ($c = \sqrt{a^2 + b^2}$)

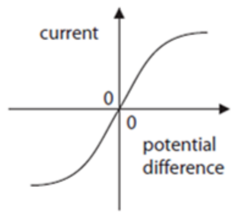
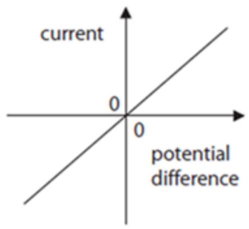
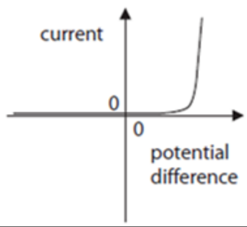
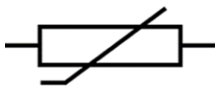
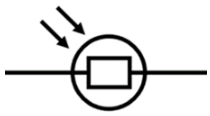
Topic 10.1: Electricity and Circuits part 1

166	Describe the basic structure of an atom.	Nucleus of positive protons and neutral neutrons. Negative electrons in energy levels around the outside.
167	 Name the electrical component represented by this symbol.	Cell
168	 Name the electrical component represented by this symbol.	Switch (open)
169	 Name the electrical component represented by this symbol.	Lamp *accept* bulb
170	 Name the electrical component represented by this symbol.	Ammeter
171	 Name the electrical component represented by this symbol.	Voltmeter
172	 Name the electrical component represented by this symbol.	(fixed) Resistor
173	 Name the electrical component represented by this symbol.	Variable resistor

174	Which measurement has the standard unit A?	Current *accept* I
175	Which measurement has the standard unit C?	Charge *accept* Q
176	What is being defined here: 'the rate of flow of charge'?	(electrical) current
177	State the equation that shows the relationship between charge, current and time.	$Q = I \times t$ *accept* charge (C) = current (A) × time (s)
178	How many Amps (A) are in one milliamp (mA)?	0.001 Amps per milliamp *accept* 1×10^{-3}
179	How is an electrical component connected in parallel different to a component connected in series?	(Components in parallel are) On different loops of the circuit *accept reverse argument* components in series are on the same loop of the circuit.
180	State the name of the device used to measure current in an electrical circuit.	Ammeter
181	Describe how an ammeter must be connected in an electrical circuit.	In series *accept* in the same loop (as the component being measured)
182	Describe how current behaves in parallel circuits.	Current splits/re-joins at junctions. *accept* total current is conserved before and after junctions.
183	Describe how current behaves in series circuits.	Current is the same everywhere in a series circuit.
184	Which measurement has the standard unit V?	Potential difference *accept* V *accept* supply voltage
185	What is being defined here: 'one joule of energy per coulomb of charge'?	(one) Volt
186	State the equation that shows the relationship between charge, energy and potential difference.	$E = Q \times V$ *accept* Energy (J) = charge (C) × potential difference (V)
187	State the name of the device used to measure current in an electrical circuit.	Voltmeter
188	Describe how a voltmeter must be connected in an electrical circuit.	in parallel (across the component being measured) *accept* connected before and after the component
189	What is being defined here: 'opposition to the flow of charge in an electrical circuit'?	(electrical) Resistance
190	Which measurement has the standard unit Ω?	Resistance *accept* R
191	State the equation that shows the relationship between resistance, current and potential difference.	$V = I \times R$ *accept* potential difference (V) = current (A) x resistance (Ω)
192	How does the overall resistance of identical resistors compare when they are connected in series with when they are connected in parallel?	(overall resistance is) lowest for resistors connected in parallel *accept reverse argument for resistors in series*

Topic 10.2: Electricity and Circuits part 2

193	What causes the temperature of a wire to increase as current flowing through it increases (the heating effect)?	(as current increases there are) **more collisions between** (free flowing) **electrons** **and** (lattice) **ions** (and other electrons). Causing **ions** to **vibrate faster.** (so electrical energy → thermal energy)

194	Suggest at least two methods of reducing the resistance of a wire in a circuit.	(any two from...) Shorter wire; Thicker/larger diameter wire; Cool the wire; Use a lower-resistance material/better conductor.
195	 Name the component that would produce a current vs potential difference graph with this shape.	Bulb/lamp
196	 Name the component that would produce a current vs potential difference graph with this shape.	(Fixed) resistor
197	 Name the component that would produce a current vs potential difference graph with this shape.	Diode
198	Describe what happens to the resistance of a thermistor as the thermistor's temperature increases.	(resistance) **decreases** (as temperature increases)
199	Describe what happens to the resistance of an LDR (light-dependent resistor) as the intensity of light shining on the LDR increases.	(resistance) **decreases** (as light intensity increases)
200	 Name the electrical component represented by this symbol.	Diode
201	 Name the electrical component represented by this symbol.	Thermistor
202	 Name the electrical component represented by this symbol.	LDR (light dependent resistor)
203	State the equation that shows the relationship between energy, time, current and potential difference.	$E = I \times V \times t$ *accept* energy (J) = current (A) x potential difference (V) x time (s)
204	State the equation that shows the relationship between power, energy, and time.	$P = E \div t$ *accept* power (W) = energy (J) ÷ time (s)
205	Which measurement has the standard unit W?	power *accept* P
206	State the equation that shows the relationship between power, current and potential difference.	$P = I \times V$ *accept* power (W) = current (A) × potential difference (V)
207	State the equation that shows the relationship between power, current and resistance.	$P = I^2 \times R$ *accept* power (W) = current^2 (A) x resistance (Ω)
208	Describe the difference between direct current (DC) and alternating current (AC).	In direct current charge moves continuously in one direction. In alternating current charge oscillates/continually changes direction.

209	Do cells, batteries and solar panels supply direct current or alternating current?	Direct current
210	Describe at least two of the three features of UK mains electricity.	(Any two from...) **Alternating current/AC**; (potential difference of) **230 V**; (frequency of) **50 Hz**
211	Inside a three-core electrical cable in the UK there is a yellow/green wire, a brown wire and a blue wire. State the names for each of these wires.	yellow/green is **Earth**; brown is **live**; blue is **neutral**.
212	What is the potential difference between the live wire and the neutral wire connected to a UK mains electricity socket?	**230 V**
213	What is the potential difference between the live wire and the Earth wire connected to a UK mains electricity socket?	**230 V**
214	What is the potential difference between the neutral wire and the Earth wire connected to a UK mains electricity socket?	**0 V** *accept* Nothing
215	Describe how the Earth wire can prevent someone getting electrocuted if there is a fault with an electrical appliance.	(Earth wire) **provides a lower-resistance pathway for current to flow through** (than a human)
216	Describe how a fuse works.	When current exceeds a pre-determined magnitude the heating effect will melt the fuse wire, disconnecting the live wire.
217	Circuit breakers perform a similar function to fuses. Describe the ways in which circuit breakers are better than fuses.	(Circuit breakers) act quickly enough that they can prevent people getting electrocuted. (Circuit breakers) do not need to replaced once they have performed their function.

Topic 12: Magnetism and the Motor Effect

218	Name the four most common magnetic metals.	Iron, steel, nickel, and cobalt *accept* Fe, Ni and Co for the elemental metals.
219	Describe how a permanent magnet is different from an induced magnet.	Permanent magnet creates its own magnetic field. Induced magnet only has a magnetic field due to being in the magnetic field of another magnet (e.g. a paper clip hanging from a bar magnet)
220	Describe how like magnetic poles interact (N + N or S + S)	repel
221	Describe how opposite magnetic poles interact (N + S)	attract
222	What is being defined here: 'The region of space around a magnet where magnetic materials (and wires with currently flowing through them) experience a force'?	magnetic field
223	Describe the direction that magnetic field lines always point in.	North to south
224	What is the relationship between the strength of a magnetic field and the magnetic field lines drawn to represent it?	the stronger the magnetic field, the close the magnetic field lines are to each other.
225	What is being defined here: 'The type of magnetic field where all of the magnetic field lines are equally spaced apart and parallel to each other'?	**uniform** magnetic field

226	Describe how to use plotting compasses to show the shape of the magnetic field around a bar magnet.	• place magnet on paper, draw around it, label north and south pole. • place plotting compass at corner and mark where each end of the arrow points. • move plotting compass so start of arrows lines up with further point and mark the new furthest point • repeat until points go off the paper or back to the magnet • draw a line going through all points with arrows pointing form north to south • repeat several times but with plotting compass at different starting points
227	Describe how to work out the direction of the magnetic field around a wire with a current flowing through it using just your hand.	(Right hand grip rule) • Curl fingers of right hand as if holding a pole and stick thumb up. • Point thumb in direction of current. • Fingers show (circular) direction of magnetic field.
228	Which variables affect the strength of the magnetic field around a wire with a current flowing through it?	size/magnitude of current; distance from the wire
229	What is being defined here: 'A coil of wire (usually used to make an electromagnet by passing a current through the wire)'?	solenoid
230	Where is the magnetic field in a solenoid strongest and why?	Inside, where magnetic field lines are uniform and add together. (outside some field lines cancel each other out so it is weaker)
231	Describe how to work out the relative directions of the movement of a current-carrying wire in a magnetic field, the direction of the current in the wire and the direction of the magnetic field lines using just your hand.	(Fleming's left hand rule) • thu**m**b up to represent **m**ovement • **fi**rst finger pointing straight to represent magnetic **fi**eld • se**c**ond finger bent at 90° to first to represent **c**urrent direction.
232	State the equation that shows the relationship between magnetic flux density, force on a current-carrying conductor at right angles to the magnetic field, length of the conductor and size of the current.	$F = B \times I \times l$ *accept* force (N) = magnetic flux density (T) x current (A) x length (m)
233	Which measurement has the standard unit T (tesla)?	magnetic flux density *accept* B

Topic 13: Electromagnetic Induction

234	What is being defined here: 'A device that changes the magnitude of the potential difference of an AC power supply'?	Transformer
235	Describe how a transformer works.	• AC current flows into primary coil, creating a magnetic field. • This magnetic field induces an AC current in the secondary coil.
236	What material is typically used for the core of a transformer and why?	Iron because it is easily magnetised and demagnetised.
237	Why is electrical energy transferred through the national grid at very high voltages?	Reduces energy lost through heating effect (in transmission lines) by allowing the same power output for a lower current (because $P = I^2 \times R$)
238	What is the function of a step-up transformer?	Increases potential difference (while maintaining the same power so also decreasing current)
239	Where would you find step-up transformers in the national grid?	At power stations (to boost potential difference up really high to transmit it power long distances without losing too much energy)

240	What is the function of a step-down transformer?	Decreases potential difference (while maintaining the same power so also increasing current)
241	Where would you find step-down transformers in the national grid?	In sub-stations and houses (to lower potential difference back to safe, usable levels)
242	State the equation that shows the relationship between the potential differences across the coils in a transformer and the current flowing through the coils.	$V_1 \times I_1 = V_2 \times I_2$ *accept* potential difference across primary coil x current through primary coil = potential difference across secondary coil x current through secondary coil.

Topic 14: Particle Model

243	Describe how the particles are *arranged* in a solid substance.	touching; regular order
244	Describe how the particles are *moving* in a solid substance.	vibrating
245	Describe how the particles are *arranged* in a liquid substance.	touching; random order
246	Describe how the particles are *moving* in a liquid substance.	sliding past each other
247	Describe how the particles are *arranged* in a gaseous substance.	not touching; random order
248	Describe how the particles are *moving* in a gaseous substance.	moving freely in all directions
249	What is the change in the size and mass of particles when a substance melts?	there is no change in size or mass
250	What is being defined here: 'The average kinetic energy of particles in a substance'?	Temperature
251	What is being defined here: 'Movement energy stored in an object'?	Kinetic energy
252	What, in °C, is the coldest temperature that any object can get to?	-273 °C
253	Convert 0 K (Kelvin) in to °C (degrees Celsius).	-273 °C
254	Describe how the movement of particles changes as a solid cools down.	Vibrating/moving more slowly or lower kinetic energy
255	Describe how the movement of particles in a solid change as the solid is heated.	vibrating faster
256	If heat is transferred into a substance that is changing state, why does the temperature of the substance not rise until it has finished changing state completely?	Energy is being used to overcome forces of attraction between particles (rather than increasing the particles kinetic energy)
257	Describe how the energy stored in a substance changes as it heat up.	(kinetic/thermal) energy stored increases.
258	On a heating or cooling curve (a graph of heat energy applied vs temperature) for a pure substance, what do the flat parts of the graph indicate?	a change of state (such as melting or boiling)
259	What is being defined here: 'The amount of energy required to increase the temperature of one kilogram of a substance by one degree'?	(specific) heat capacity
260	State the equation that shows the relationship between specific heat capacity, change in thermal energy, mass and temperature.	$\Delta Q = m \times c \times \Delta\theta$ *accept* change in thermal energy (J) = mass (kg) x specific heat capacity (J/kg°C) x change in temperature (°C)
261	Which measurement has the standard unit J/kg°C?	(specific) heat capacity *accept* c
262	What is being defined here: 'The amount of energy required to melt one kilogram of a substance'? (the same as the amount of energy transferred to the surrounding when one kilogram of the substance freezes)	Latent heat of fusion

263	What is being defined here: 'The amount of energy required to boil one kilogram of a substance'? (the same as the amount of energy transferred to the surrounding when one kilogram of the substance condenses)	Latent heat of vaporisation
264	Which measurement has the standard unit J/kg?	Latent heat (of fusion or of vaporisation) *accept* L
265	State the equation that shows the relationship between latent heat, change in thermal energy and mass.	$\Delta Q = m \times L$ accept change in thermal energy (J) = mass (kg) x latent heat (of fusion or vaporisation) (J/kg)
266	State the equation that shows the relationship between density, volume and mass.	$\rho = m \div V$ *accept* density (kg/m³) = mass (kg) ÷ volume (m³) accept density (g/cm³) = mass (g) ÷ volume (cm³)
267	How many centimetres cubed (cm³) are in one metre cubed (m³)?	1000 (cm³ per m³)
268	Which measurement has the standard unit kg/m³?	density *accept* ρ
269	Describe how you could record the density of an irregularly shaped object.	• Record mass (using a top pan balance) • Record volume of liquid object displaces when submerged (in a measuring cylinder/density can/eureka can) • Divide mass by volume.
270	What causes the pressure of a gas on a surface?	the force of the gas particles colliding with the surface.
271	What is being defined here: 'The temperature at which particles of substance have no movement energy'	absolute zero *accept* 0 K *accept* -273(.15) °C
272	For a fixed volume of gas, how does the pressure change if the temperature in Kelvin doubles?	Pressure also doubles *accept* pressure is directly proportional to temperature (in Kelvin) *accept* there is a doubling relationship

Topic 15: Forces and Matter

273	Describe the differences between plastic (inelastic) and elastic distortion	Elastic distortion means materials return to their original shape when the force that changed their shape is no longer being applied. Plastic/inelastic do not return to their original shape.
274	What is the minimum number of forces that must be applied to an object to stretch, bend, or compress it?	Two
275	What is being defined here: 'The stiffness of a spring. Measured by recording how many Newtons of force are required to stretch the spring per metre'?	Spring constant *accept* k
276	State the equation that shows the relationship between the extension of a spring, its spring constant and the force applied to the spring.	$F = k \times x$ *accept* force (N) = spring constant (N/m) x extension (m)
277	Which measurement has the standard unit N/m?	Spring constant *accept* k
278	Describe how to calculate the extension of a spring when a force/load is applied to it.	• Measure length of spring with no force applied • Measure length of spring with force applied • extension = length of stretched spring - length of unstretched spring
279	Describe how the extension of an elastic material changes when the force applied to it is doubled.	Extension also doubles *accept* extension is directly proportional to force applied/linear *accept* there is a doubling relationship

280	What do we name the point where F = k × *x* no longer applies for a material (where a graph of force vs extension stops being a straight line)	the elastic limit
281	State the equation that shows the relationship between the extension of a spring, its spring constant and the work done in stretching the spring.	$E = \frac{1}{2} \times k \times x^2$ *accept* work done (J) = ½ × spring constant (N/m) × extension^2 (m)
282	Describe how to use a graph of force vs extension to determine the work down in stretching a spring.	(Work done is) area under the graph

Periodic table of the Elements.

1 H Hydrogen 1.008																	2 He Helium 4.003
3 Li Lithium 6.94	4 Be Beryllium 9.012											5 B Boron 10.81	6 C Carbon 12.011	7 N Nitrogen 14.007	8 O Oxygen 15.999	9 F Fluorine 18.998	10 Ne Neon 20.180
11 Na Sodium 22.990	12 Mg Magnesium 24.305											13 Al Aluminum 26.982	14 Si Silicon 28.085	15 P Phosphorus 30.974	16 S Sulfur 32.06	17 Cl Chlorine 35.45	18 Ar Argon 39.948
19 K Potassium 39.098	20 Ca Calcium 40.078		21 Sc Scandium 44.956	22 Ti Titanium 47.867	23 V Vanadium 50.942	24 Cr Chromium 51.996	25 Mn Manganese 54.938	26 Fe Iron 55.845	27 Co Cobalt 58.933	28 Ni Nickel 58.693	29 Cu Copper 63.546	30 Zn Zinc 65.38	31 Ga Gallium 69.723	32 Ge Germanium 72.630	33 As Arsenic 74.922	34 Se Selenium 78.97	35 Br Bromine 79.904	36 Kr Krypton 83.798
37 Rb Rubidium 85.468	38 Sr Strontium 87.62		39 Y Yttrium 88.906	40 Zr Zirconium 91.224	41 Nb Niobium 92.906	42 Mo Molybdenum 95.95	43 Tc Technetium [97]	44 Ru Ruthenium 101.07	45 Rh Rhodium 102.906	46 Pd Palladium 106.42	47 Ag Silver 107.868	48 Cd Cadmium 112.414	49 In Indium 114.818	50 Sn Tin 118.710	51 Sb Antimony 121.760	53 Te Tellurium 127.60	53 I Iodine 126.904	54 Xe Xenon 131.293
55 Cs Cesium 132.905	56 Ba Barium 137.327	* 57 - 70	71 Lu Lutetium 174.967	72 Hf Hafnium 178.49	73 Ta Tantalum 180.948	74 W Tungsten 183.84	75 Re Rhenium 186.207	76 Os Osmium 190.23	77 Ir Iridium 192.217	78 Pt Platinum 195.084	79 Au Gold 196.997	80 Hg Mercury 200.592	81 Tl Thallium 204.38	82 Pb Lead 207.2	83 Bi Bismuth 208.980	84 Po Polonium [209]	85 At Astatine [210]	86 Rn Radon [222]
87 Fr Francium [223]	88 Ra Radium [226]	** 89 - 102	103 Lr Lawrencium [262]	104 Rf Rutherfordium [267]	105 Db Dubnium [270]	106 Sg Seaborgium [269]	107 Bh Bohrium [270]	108 Hs Hassium [270]	109 Mt Meitnerium [278]	110 Ds Darmstadtium [281]	111 Rg Roentgenium [281]	112 Cn Copernicium [285]	113 Nh Nihonium [286]	114 Fl Flerovium [289]	115 Mc Moscovium [289]	116 Lv Livermorium [293]	117 Ts Tennessine [293]	118 Og Oganesson [294]

*Lanthanide series	57 La Lanthanum 138.905	58 Ce Cerium 140.116	59 Pr Praseodymium 140.908	60 Nd Neodymium 144.242	61 Pm Promethium [145]	62 Sm Samarium 150.36	63 Eu Europium 151.964	64 Gd Gadolinium 157.25	65 Tb Terbium 158.925	66 Dy Dysprosium 162.500	67 Ho Holmium 164.930	68 Er Erbium 167.259	69 Tm Thulium 168.934	70 Yb Ytterbium 173.045
**Actinide series	89 Ac Actinium [227]	90 Th Thorium 232.038	91 Pa Protactinium 231.036	92 U Uranium 238.029	93 Np Neptunium [237]	94 Pu Plutonium [244]	95 Am Americium [243]	96 Cm Curium [247]	97 Bk Berkelium [247]	98 Cf Californium [251]	99 Es Einsteinium [252]	100 Fm Fermium [257]	101 Md Mendelevium [258]	102 No Nobelium [259]

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