Science Physics Assessment Levels

I can do this		9=		8+	8=	8-	7+	7=	7-	6+	6=	6-	5+	5=	5-	4+	4=	4-	3+	3=	3-	2+	2=	2-	1+	1=	1-	F+	F=	F-
Energy transfers				Make calculations of the energy changes associated with changes in a system, recalling or selecting the relevant equations for mechanical, electrical, and thermal processes; thereby express in quantitative form and on a common scale the overall redistribution of energy in the system (1a, 1c, 3c).			Describe ways to increase efficiency			Calculate the amounts of energy associated with a moving body, a stretched spring, and an object raised above ground level Describe with examples where there are energy transfers in a system, that there is no net change to the total energy of a closed system (qualitative only) Calculate relevant values of stored energy and energy transfers; convert between newton-metres and joules (1c, 3c)			Relate the term 'energy' to the ability of an object to do some useful work. Explain, with reference to examples, the definition of power as the rate at which energy is transferred Calculate energy efficiency for any energy transfer Use the relationship between work done, force, and distance moved along the line of action of the force and describe the energy transfer involved.			Find the power of a device from the energy it uses over a certain time. Compare two devices in terms of the ratio of their powers. Can calculate the efficiency of a device and work out the amount of energy or power it 'loses'. Describe all the changes involved in the way energy is stored when a system changes, for common situations: appropriate examples might be an object projected upwards or up a slope, a moving object hitting an obstacle, an object being accelerated by a constant force, a vehicle slowing down, bringing water to a boil in an electric kettle Describe, with examples, how in all system changes, energy is dissipated, so that it is stored in less useful ways			Recall the four different ways that energy can be shifted from one store to another, giving examples. Explain how frictional heating may be useful. Compare two devices in terms of which is more or less efficient and why. Plot an appropriate graph of temperature against time in an investigation into different types of insulation, including use of best fit curved lines where data requires			State that energy can be transferred from one store to another, or from one object to another, and that this is related to an observable change. Explain the law of conservation of energy, using examples, and suggest ways in which energy may be 'lost' from a system. Relate two devices in terms of their power, by correctly stating which is more powerful than the other. Plot an appropriate graph of temperature against time in an investigation into different types of insulation.			List the eight different energy stores, and give examples of situations where energy is stored in these ways. State the law of conservation of energy, giving an example of where the 'lost' energy has gone to.					

Forces and effects			Explain with examples that motion in a circular orbit involves constant speed but changing velocity (qualitative only) Explain that inertial mass is a measure of how difficult it is to change the velocity of an object and that it is defined as the ratio of force over acceleration	Use vector diagrams to illustrate resolution of forces, a net force, and equilibrium situations (scale drawings only) (4a, 5a, 5b) Describe examples of the forces acting on an isolated solid object or system; Describe, using free body diagrams, examples where several forces lead to a resultant force on an object and the special case of balanced forces when the resultant force is zero (qualitative only) Define momentum and describe examples of momentum in collisions.	Apply formulae relating force, mass and relevant physical constants, including gravitational field strength, to explore how changes in these are inter-related (1c, 3b, 3c) Apply formulae relating force, mass, velocity and acceleration to explain how the changes involved are inter-related (3b, 3c, 3d) Estimate, for everyday road transport, the speed, accelerations and forces involved in large accelerations (1d, 2d, 2c, 2f, 2h, 3c).	Use a graph of extension against force to prove or disprove Hooke's Law for the object being stretched. Use Hooke's Law to calculate the extension for a given force, or vice-versa. Explain how stretching and releasing a spring transfers energy into and out of its elastic store. recall examples of ways in which objects interact: by gravity, electrostatics, magnetism and by contact (including normal contact force and friction), and describe how such examples involve interactions between pairs of objects which produce a force on each object; represent such forces as vectors	Name the less commonly used forces (i.e. support force, upthrust, surface tension, tension) Add or subtract co-linear forces to find the size and direction of the resultant force. Explain the difference between elastic and plastic deformation. Identify which regions of a graph of extension against force are due to elastic and which are due to plastic deformation. Give examples of situations in which friction is useful, & in which it's a nuisance.	Name the most commonly used forces (i.e. applied forces (push and pull), gravity, friction, magnetism, electrostatic force, air resistance) Label the forces acting on an object in a force diagram. Explain the difference between a contact and a non-contact force, and name some examples of each. Recall that a resultant force is needed to cause acceleration.	Recall that a force can change an object's speed, direction, or shape. Name some of the common forces seen in everyday life. Describe friction as a force which opposes motion.	Compare how some things move on different surfaces Explain that unsupported objects fall towards the Earth because of the force of gravity acting between the Earth and the falling object. Identify the effects of air resistance, water resistance and friction that act between moving surfaces. Recognise that some mechanisms, including levers, pulleys and gears, allow a smaller force to have a greater effect.
Electricity		Use graphs to explore whether circuit elements are linear or non-linear and relate the curves produced to their function and properties (4c, 4d, 4e).	Apply the equations relating p.d., current, quantity of charge, resistance, power, energy, and time, and solve problems for circuits which include resistors in series, using the concept of equivalent resistance (1c, 3b, 3c, 3d)	Explain how the power transfer in any circuit device is related to the p.d. across it and the current, and to the energy changes over a given time Recall that, in the national grid, electrical power is transferred at high voltages from power stations, and then transferred at lower voltages in each locality for domestic use, and explain how this system is an efficient way to transfer energy. Recall that current (I) depends on both resistance (R) and potential difference (V) and the units in which these are measured; Recall and apply the relationship between I, R and V, and that for some resistors the value of R remains constant but that in others it can change as the current changes; Explain the design and use of circuits to explore such effects – including for lamps, diodes, thermistors and LDRs.	Identify that a p.d. across a circuit component represents a transfer of energy through that component, and that the higher the p.d. the higher the amount of energy transferred per second recall that current is a rate of flow of charge, that for a charge to flow, a source of potential difference and a closed circuit are needed and that a current has the same value at any point in a single closed loop; Recall and use the relationship between quantity of charge, current and time Calculate the currents, potential differences and resistances in d.c. series circuits, and explain the design and use of such circuits for measurement and testing purposes; Represent them with the conventions of positive and negative terminals, and the symbols that represent common circuit elements, including diodes, LDRs and thermistors. Describe how, in different domestic devices, energy is transferred from batteries and the a.c. mains to the energy of motors or of heating devices	Recall and use the relationship: p.d. = I × R. Know the rules for current and p.d. in parallel circuits. Can apply the rules for current and p.d. in series and parallel circuits to find the missing value in a given circuit Describe the difference between series and parallel circuits, explain why, if two resistors are in series the net resistance is increased, whereas with two in parallel the net resistance is decreased (qualitative explanation only)	Recall that a larger p.d. across a conductor will make a larger current flow through it. Predict how differing values of resistance will affect the amount of current that flows. Predict how changing the thickness and length of a wire will affect its resistance (qualitative). Recall the rules for current and p.d. in series circuits.	State that an electric current is a flow of electric charge, and state the correct direction for the flow of electrons, and of positive and negative ions. Correctly position an ammeter and a voltmeter in a circuit.	Recall some basic electrical circuit symbols and the basic differences between series and parallel circuits. State the difference between conductors and insulators, and common materials for each. State that a potential difference and a complete circuit are both necessary for a current to flow. Recall the units for current, p.d. and resistance.	Identify common appliances that run on electricity. Associate the brightness of a lamp or the volume of a buzzer with

Energy resources				Explain patterns and trends in the use of energy resources.	List and explain the pros and cons of different types of energy generation.	Give suitable locations for different types of power plants, with reasons. Describe the main energy sources available for use on Earth (including fossil fuels, nuclear fuel, bio-fuel, wind, hydro-electricity, the tides and the Sun), Compare the ways in which they are used and distinguish between renewable and non-renewable sources	Identify the differences between HEP, tidal power and wave power and state where the energy comes from in each case. Describe the workings of a typical power station. Describe how certain renewable energy resources are harnessed	State that the burning of fossil fuel has lead to increased levels of CO_2 in the air, and that this is causing global warming. List a good number of renewable energy resources. State the energy stored in fossil fuels originally came from the sun. Explain the difference between renewable and non-renewable energy resources, and recall which energy resources are which.	State that we receive energy from the sun in the form of light and infra-red radiation. List the three fossil fuels, and can describe how fossil fuels were formed. Name some typical uses of fossil fuels, and the names of some fuels derived from crude oil.	
Magnets and electromagnets	Apply the equation that links the force on a conductor to the strength of the field, the current and the length of conductor to calculate the forces involved Recall that the strength of the field depends on the current and the distance from the conductor, and explain how solenoid arrangements can enhance the magnetic effect	Explain how this force is used to cause rotation in electric motors. Recall that a change in the magnetic field around a conductor can give rise to an induced potential difference across its ends, which could drive a current, generating a magnetic field that would oppose the original change; Hence explain how this effect is used in an alternator to generate a.c., and in a dynamo to generate d.c. Describe the characteristics of the magnetic field of a magnet, showing how strength and direction change from one point to another Describe how to show that a current can create a magnetic effect and describe the directions of the magnetic field around a conducting wire	Explain how the effect of an alternating current in one circuit in inducing a current in another is used in transformers and how the ratio of the p.d.'s across the two depends on the ratio of the numbers of turns in each. Apply the equations linking the p.d.s and numbers of turns in the two coils of a transformer, to the currents and the power transfer involved, and relate these to the advantages of power transmission at high voltages (1c, 3b, 3c). Describe the attraction and repulsion between unlike and like poles for permanent magnets and describe the difference between permanent and induced magnets Explain how the behaviour of a magnetic compass is related to evidence that the core of the Earth must be magnetic. Explain the action of the microphone in converting the pressure variations in sound waves into variations in current in electrical circuits, and the reverse effect as used in loudspeakers and headphones.	Describe how a magnet and a current-carrying conductor exert a force on one another and show that Fleming's left-hand rule represents the relative orientations of the force, the conductor and the magnetic field	make calculations using ratios and proportional reasoning to convert units and to compute rates	Recall the pattern of the magnetic field produced by a straight wire, a flat coil and a solenoid. Explain the operation of a loudspeaker in terms of magnetic fields. Explain the operation of an electric motor in simple terms.	Build an electromagnet and test ways of increasing its strength. List the stages in the operation of an electric bell. Use the domain theory of magnetism to explain magnetisation and demagnetisation.	State that repulsion, not attraction, is the test of whether an object is a magnet, rather than a magnetic material. Recall how soft and hard magnetic materials make temporary and permanent magnets respectively. Explain why the earth's geographical north pole is a magnetic south pole. Trace a magnetic field using iron fillings or plotting compasses.	Name some common magnetic materials and realise that not all metals are magnetic. Recall that a pole is the strongest part of a magnet, and that there are two poles on every magnet. State some uses of electromagnets.	

Motion				Explain the vector-scalar distinction as it applies to displacement, distance, velocity and speed Recall typical speeds encountered in everyday experience for wind and sound, and for walking, running, cycling and other transportation systems; Recall the acceleration in free fall and estimate the magnitudes of everyday accelerations.	Find speed from the gradient of a distance-time graph. Find acceleration from the gradient of a speed-time graph. Apply Newton's Second Law in calculations relating forces, masses and accelerations Recall Newton's Third Law and apply it to examples of equilibrium situations Apply formulae relating distance, time and speed, for uniform motion, and for motion with uniform acceleration, and calculate average speed for non-uniform motion (1a, 1c, 2f, 3c) Estimate how the distances required for road vehicles to stop in an emergency, varies over a range of typical speeds (1c, 1d, 2c, 2d, 2f, 2h, 3b, 3c)	Relate the forces acting on a parachutist to a speed-time graph of his/her motion. Recall the conditions for terminal velocity. State that a force on an object at 90° to its direction of motion will make it move in a circle at a constant speed. Make measurements of distances and times, calculate speeds, and make and use graphs of these to determine the speeds and accelerations involved. Apply Newton's First Law to explain the motion of objects moving with uniform velocity and also objects where the speed and/or direction change Relate changes and differences in motion to appropriate distance-time, and velocity-time graphs, and interpret lines, slopes and enclosed areas in such graphs (4a, 4b, 4c, 4d, 4f)	Explain and apply the relationship between the mass of an object and its weight. Realise that the acceleration of free fall does not depend on an object's weight. Plot and interpret graphs of speed against time. Describe the effects that air resistance and streamlining have on how an object moves.	Recall that if the forces on an object are balanced it is in equilibrium, with a constant speed and direction. Compare forwards and backwards forces to find the direction of the resultant force, and use this to predict the direction of acceleration. Plot and interpret graphs of distance against time.	State that a force can change an object's speed or direction. Can use the equation: average speed = distance travelled ÷ time taken Calculate the relative speed of two moving objects.	
Domestic and static electricity				Recall the differences in function between the live, neutral and earth mains wires, and the potential differences between these wires; hence explain that a live wire may be dangerous even when a switch in a mains circuit is open, and explain the dangers of providing any connection between the live wire and earth. Explain the concept of an electric field and how it helps to explain the phenomena of static electricity.	Recall and use the relationship: charge = current × time. Describe, with examples, the relationship between the power ratings for domestic electrical appliances and the changes in stored energy when they are in use. Recall that the domestic supply in the UK is a.c., at 50Hz and about 230 volts, explain the difference between direct and alternating voltage.	Recall and use the relationship: power = current × potential difference Recall and use the relationship: energy = power × time, to find energy in both joules and kilowatthours. Name the situations in which we want to measure energy in joules and in which we want to measure energy in kilowatt-hours. Explain how objects can become charged by induction. Describe the production of static electricity, and sparking, by rubbing surfaces, and evidence that charged objects exert forces of attraction or repulsion on one another when not in contact; explain how transfer of electrons between objects can explain the phenomena of static electricity	State that we pay for the electrical energy we use, not for the power of the device. Explain how objects can become charged by friction in terms of transfer of electrons. Explain why the cable to an appliance which draws a large current needs a thicker wire than the cable to an appliance which draws a smaller current.	Calculate the cost of the electricity used from two meter readings and the price per unit. Explain why it is easier to charge an insulator than to charge a conductor. State that an electric current is a flow of charge.	Recall the charge combinations that attract or repel due to the electrostatic force. State that the p.d. of mains electricity is always 230V. State that a high power appliance draws more current from the mains than a low power one.	

Waves and sound		Describe, with examples, processes which convert wave disturbances between sound waves and vibrations in solids, and explain why such processes only work over a limited frequency range, and the relevance of this to human audition	Recall that different substances may absorb, transmit, refract, or reflect these waves in ways that vary with wavelength; Explain how some effects are related to differences in the velocity of the waves in different substances Explain, in qualitative terms, how the differences in velocity, absorption and reflection between different types of waves in solids and liquids can be used both for detection and for exploration of structures which are hidden from direct observation, notably in our bodies, in the earth's core and in deep water. Recall that radio waves can be produced by or can themselves induce oscillations in electrical circuits	Apply formulae relating velocity, frequency and wavelength (1c, 3c) Show how changes in velocity, frequency and wavelength, in transmission of sound waves from one medium to another, are inter-related (1c, 3c).	Describe wave motion in terms of amplitude, wavelength, frequency and period; Define wavelength and frequency and describe and apply the relationship between these and the wave velocity Describe the difference between transverse and longitudinal waves Describe how ripples on water surfaces are examples of transverse waves whilst sound waves in air are longitudinal waves, and how the speed of each may be measured; describe evidence that in both cases it is the wave and not the water or air itself that travels. Describe the effects of reflection, transmission, and absorption of waves at material interfaces	Compare in simple terms the pitch and loudness (or frequency and amplitude) of two musical notes from their oscilloscope traces. Explain why the speed of sound is much greater in solids and liquids than in air.	Explain the meaning of frequency, and equate a higher frequency sound with a higher pitch. Equate a longer wavelength sound with a lower note, and understand the implications of this for the size of musical instruments. Recall that if the frequency of a wave doubles, its wavelength halves.	Measure the wavelength and amplitude of a transverse wave, and the wavelength of a longitudinal wave. State that sound waves require a medium to propagate, while light waves do not. Explain how sound waves are produced and propagated. State and explain some uses of ultrasound.	State that light travels much faster than sound, and over short distances can be considered to be almost instantaneous. Recall that a wave involves a transfer of energy without the overall movement of the medium. Distinguish between transverse and longitudinal waves. State that sound is a longitudinal wave while light is a transverse wave.	
Light					Recall that changes in atoms and nuclei can also generate and absorb radiations over a wide frequency range Give examples of some practical uses of electromagnetic waves in the radio, microwave, infra-red, visible, ultra-violet, X-ray and gamma-ray regions and describe how ultra-violet waves, X-rays and gamma-rays can have hazardous effects, notably on human bodily tissues.	Draw a ray diagram to show how an image is formed in a mirror. Explain how surfaces appear coloured by reflecting or absorbing combinations of the primary colours. Recall that light is an electromagnetic wave Recall that electromagnetic waves are transverse, are transmitted through space where all have the same velocity, and explain, with examples, that they transfer energy from source to absorber Describe the main groupings of the spectrum – radio, microwave, infra-red, visible (red to violet), ultra-violet, X-rays and gamma-rays, that these range from long to short wavelengths and from low to high frequencies, and that our eyes can only detect a limited range. Use ray diagrams to illustrate reflection, refraction and the similarities and differences between convex and concave lenses (qualitative only). Explain how colour is related to differential absorption, transmission, specular Construct two-dimensional ray	Explain the difference between a real and a virtual image. Describe how a pinhole camera and a lens camera form an image. Describe how the primary colours of light combine to make the secondary colours.	Compare an object with its image in a mirror. Explain the difference between specular and diffuse reflection. Describe how a convex lens focuses light. State that light changes direction when it passes from one medium to another, and that this is called refraction. Explain how we are able to see a non-luminous object.	Explain the difference between luminous and non-luminous objects. State that light travels in straight lines. Recall that sound waves require a medium to propagate, while light waves do not. State the law of reflection.	

Application of forces		Calculate the differences in pressure at different depths in a liquid (1c, 3c).	Estimate the forces involved in typical situations on a public road.	Explain why pressure in a liquid varies with depth and density and how this leads to an upwards force on a partially submerged object; Describe the factors which influence floating and sinking. Explain how doing work on a gas can increase its temperature (e.g. bicycle pump).	Describe the difference between elastic and inelastic distortions caused by stretching forces; Calculate the work done in stretching; Describe the relationship between force and extension for a spring and other simple systems; Describe the difference between linear and non-linear relationships between force and extension, and calculate a spring constant in linear cases. Describe examples in which forces cause rotation; Define and calculate the moment of the force in such examples. Explain how levers and gears transmit the rotational effects of forces.	Explain upthrust in terms of the water pressure at differing depths on an object. Define weight, describe how it is measured and Describe the relationship between the weight of that body and the gravitational field strength Explain, with examples, that stretch, bend or compress an object, more than one force has to be applied Recall that the pressure in fluids causes a force normal to any surface, and use the relationship between the force, the pressure, and the area in contact Describe a simple model of the Earth's atmosphere and of atmospheric pressure, and explain why atmospheric pressure varies with height above the surface Explain methods of measuring human reaction times and recall typical results Explain the factors which affect the distance required for road transport vehicles to come to rest in emergencies and the implications for safety	Apply the principle of moments to determine whether an object is balanced, or to work out an unknown force or distance. State that upthrust is equal to the weight of water displaced by an object. Explain why pressure increases with depth in a fluid. Explain the effect of a differing internal and external pressure on an object.	Use the following equations: turning moment of a force = force × perpendicular distance from pivot density = mass ÷ volume pressure = force ÷ area State why someone may wish to use a lever, and explain the operation of some typical levers. Give examples of situations in which a high or a low pressure is required.	State that a see-saw with different weights on either side could balance, if the heavier weight is closer to the pivot. Predict whether an object will float or sink from knowledge of its density compared to that of water.	
Heat transfer		Apply the relationship between change in internal energy of a material and its mass, specific heat capacity and temperature change to calculate the energy change involved; Apply the relationship between specific latent heat and mass to calculate the energy change involved in a change of state (1a, 3c, 3d).	Describe and calculate the changes in energy involved when a system is changed by heating (in terms of temperature change and specific heat capacity), by work done by forces and by work done when a current flows	Explain how the temperature of a body is related to the balance between incoming radiation absorbed and radiation emitted; Illustrate this balance using everyday examples and the example of the factors which determine the temperature of the earth. Define the term specific heat capacity and distinguish between it and the term specific latent heat Recall that gases can be compressed or expanded by pressure changes and that the pressure produces a net force at right angles to any surface explain how increasing the volume in which a gas is contained, at constant temperature can lead to a decrease in pressure	Explain that all bodies emit radiation and that the intensity and wavelength distribution of any emission depends on their temperatures Describe how, when substances melt, freeze, evaporate, condense or sublimate, mass is conserved, but that these physical changes differ from chemical changes because the material recovers its original properties if the change is reversed. Explain how the motion of the molecules in a gas is related both to its temperature and its pressure: hence explain the relation between the temperature of a gas and its pressure at constant volume (qualitative only). Apply the relationship between density mass and volume to changes where mass is conserved (1a, 1b, 1c, 3c)	Explain why metals are good conductors of heat due to movement of free electrons. Apply knowledge of good and bad emitters of heat radiation to real life situations. Explain ways of reducing unwanted energy transfer e.g. through lubrication, thermal insulation; Describe the effects, on the rate of cooling of a building, of thickness and thermal conductivity of its walls (qualitative only) Define density and explain the differences in density between the different states of matter in terms of the arrangements of the atoms or molecules Describe how heating a system will change the energy stored within the system and raise its temperature or produce changes of state	Explain how heat transfers via each of the three methods. Apply knowledge of convection currents to real life situations. Apply knowledge of good and bad absorbers of heat radiation to real life situations.	State that heat flows from hotter objects to colder ones, and that this involves a transfer of energy. State what gaining or losing heat does to the temperature or state of a material. Use the terms conductor and insulator correctly in the context of heat transfer.	State the three methods of heat transfer. State some good and bad conductors of heat. Explain why a conductor or an insulator would be desirable in a given situation.	

Exploring Space				Explain for circular orbits how the force of gravity can lead to changing velocity of a planet but unchanged speed, and explain how, for a stable orbit, the radius must change if this speed changes (qualitative only)	Recall that our sun was formed from dust and gas drawn together by gravity and explain how this caused fusion reactions, leading to equilibrium between gravitational collapse and expansion due to the fusion energy. Explain the red-shift of light from galaxies which are receding (qualitative only), that the change with distance of each galaxy's speed is evidence of an expanding universe and hence explain the link between this evidence and the Big-Bang model.	Describe how the tilt of the earth's axis gives rise to the seasons. Describe how the moon's orbit gives rise to the phases of the moon. Name in order all of the stages in a star's lifetime. Recall the main features of our solar system, including the similarities and distinctions between	Define the meaning of the term 'light year'. State that, due to the finite speed of light, we see objects further away from us as they were longer ago.	Recall some of the uses of artificial satellites. Describe how human understanding of the solar system has developed over time. State why space exploration has mainly involved robots rather than humans.	Describe how a solar eclipse occurs. Describe how a lunar eclipse occurs. Name some of the stages in a star's lifetime.	
Radioactivity			Calculate the net decline, expressed as a ratio, in a radioactive emission after a given number of half-lives (1c, 3d). Describe how and why the atomic model has changed over time Use names and symbols of common nuclei and particles to write balanced equations that represent radioactive decay balance equations representing alpha-, beta- or gamma-radiations in terms of the masses, and charges of the atoms involved (1b, 1c, 3c)	Recall that atomic nuclei are composed of both protons and neutrons, that the nucleus of each element has a characteristic positive charge, but that elements can differ in nuclear mass by having different numbers of neutrons Relate differences between isotopes to differences in conventional representations of their identities, charges and masses. Recall the differences between contamination and irradiation effects and compare the hazards associated with these two. Explain why the hazards associated with radioactive material differ according to the half-life involved Describe the different uses of nuclear radiations for exploration of internal organs, and for control or destruction of unwanted tissue.	Recall that in each atom its electrons are arranged at different distances from the nucleus, that such arrangements may change with absorption or emission of electromagnetic radiation and that atoms can become ions by loss of outer Electrons Recall that some nuclei are unstable and may emit alpha particles, beta particles, or neutrons, and electromagnetic radiation as gamma rays; relate these emissions to possible changes in the mass or the charge of the nucleus, or both Explain the concept of half-life and how this is related to the random nature of radioactive decay Recall that some nuclei are unstable and may split, and relate such effects to radiation which might emerge, to transfer of energy to other particles and to the possibility of chain reactions Describe the process of nuclear fusion and recall that in this process some of the mass may be converted into the energy of radiation.	Describe the atom as a positively charged nucleus surrounded by negatively charged electrons, with the nuclear radius much smaller than that of the atom and with almost all of the mass in the nucleus. Recall the typical size (order of magnitude) of atoms and small molecules. Recall the differences in the penetration properties of alpha-particles, beta-particles and gamma-rays				