GCSE (9-1)

Combined Physics 1

### Topics common to Paper 1 and Paper 2

#### Topic 1 – Key concepts of physics

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| **Students should:** | | **Maths skills** |
| 1.1 | Recall and use the SI unit for physical quantities:  M metre (distance), kg kilogramm (mass), s second (time),  *A ampere (current), K Kelvin (absolute temperature), mol mole (amount of chemical substance), Hz Hertz (frequency), N Newton (Force and weight), J Joule (energy), W Watts (power), Pa Pascal (pressure), C Coulomb (electrical charge), V Volts (Voltage/potential difference), T Tesla (magnetic flux density), Ω Ohm (electrical resistance)* |  |
| 1.2 | Recall and use multiples and sub-multiples of units, including giga (G), mega (M), kilo (k), centi (c), milli (m), micro (μ) and nano (n).  *This often involves multiplying or dividing by 1000. For example 1 kilogramme is 1000 grams. 100 micrometres is 0.1 millimetres. Careful with centi as centimetres are a hundredth of a metre.* | 3c |
| 1.3 | Be able to convert between different units, including hours to seconds | 1c |
| 1.4 | Use significant figures and standard form where appropriate  *Remember 1.23 is 3 significant figures and so is 0.123.*  *100000 is 1 x 105* | 1b |

### Topics for Paper 1

#### Topic 2 – Motion and forces

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| **Students should:** | | **Maths skills** |
| 2.1 | Explain that a scalar quantity has magnitude (size) but no specific direction |  |
| 2.2 | Explain that a vector quantity has both magnitude (size) and a specific direction | 5b |
| 2.3 | Explain the difference between vector and scalar quantities | 5b |
| 2.4 | Recall vector and scalar quantities, including: a displacement/distance  b velocity/speed  c acceleration   1. force 2. weight/mass f momentum g energy |  |
| 2.5 | Recall that velocity is speed in a stated direction | 5b |
| 2.6 | Recall and use the equations:   1. (average) speed *(metre per second, m/s) = distance (metre, m) ÷ time (s)* 2. distance travelled *(metre, m) = average speed (metre per second, m/s) × time (s)* | 1a, 1c, 1d 2a  3a, 3c, 3d |
| 2.7 | Analyse distance/time graphs including determination of speed from the gradient.  *Gradient is rise over run between 2 points using the numbers on a graph scale.* | 2a  4a, 4b, 4d, 4e |
| 2.8 | **Recall** and use the equation:  acceleration (metre per second squared, m/s2) = change in velocity (metre per second, m/s) ÷ time taken (second, s)  *v* *u*  *a*   *t* | 1a, 1c, 1d 2a  3a, 3b, 3c, 3d |
| 2.9 | Use the equation:  *v*2 *u* 2 2 *a* *x*.  *v is final velocity, u is start velocity, a is acceleration and x is distance travelled.* | 1a, 1c, 1d 2a  3a, 3c, 3d |

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| **Students should:** | | **Maths skills** |
| 2.10 | Analyse velocity/time graphs to:   1. compare acceleration from gradients qualitatively. 2. calculate the acceleration from the gradient (for uniform acceleration only). 3. determine the distance travelled using the area between the graph line and the time axis (for uniform acceleration only).   a *This means a steeper line shows a larger acceleration.*  *b Gradient is rise over run between 2 points using the numbers on a graph scale.*  *c This means the area under the graph. It will be a triangle, square/rectangle or a combination of both.* | 1a, 1c, 1d 2a  4a, 4b, 4c, 4d, 4e, 4f  5c |
| 2.11 | Describe a range of laboratory methods for determining the speeds of objects such as the use of light gates  *You can measure the distance between 2 points and time an object between them. Then s = d/t.*  *Light gates and a computer will do all the calculations of time and distance for you* | 1a, 1d  2a, 2b, 2c, 2f, 2h  3a, 3c, 3d  4a, 4c |
| 2.12 | Recall some typical speeds encountered in everyday experience   * *wind (5-20m/s) and sound (340m/s), and for walking (1-2 m/s), running (3m/s), cycling (5-6m/s) and other transportation systems. Eg cars typically 13m/s in towns or 30m/s on a motorway)* |  |
| 2.13 | Recall that the acceleration, *g*, in free fall is 10 m/s2 and be able to estimate the magnitudes of everyday accelerations by finding their change in velocity and estimating how many seconds they take to speed up or slow down and then use the acceleration equations. | 1d  2h |
| 2.14 | Recall Newton’s first law and use it in the following situations:  The first law says a resultant force on an object will change its speed or direction.   1. where the resultant force on a body is zero, i.e. the body is moving at a constant velocity or is at rest. 2. where the resultant force is not zero, i.e. the speed and/or direction of the body change(s).   *a Here the object will continue doing what it was doing before either constant velocity or stationary.*  *b The resultant force will make the object speed up if the force is in the direction of movement or it will slow down if the force is against the direction of movement.* | 1a, 1d 2a  3a, 3c, 3d |
| 2.15 | **Recall** and use Newton’s second law as:  The force on an object is directly proportional to the acceleration.force (newton, N) = mass (kilogram, kg) × acceleration (metre per second squared, m/s2)  *F* *m* *a* | 1a, 1c, 1d 2a  3a, 3b, 3c, 3d |
| 2.16 | Define weight, **recall** and use the equation:  Weight is the force on an object due to gravity/  weight (newton, N) = mass (kilogram, kg) × gravitational field strength (newton per kilogram, N/kg)  *W* *m* *g* | 1a, 1c, 1d 2a  3a, 3b, 3c, 3d |
| 2.17 | Describe how weight is measured. Use a Newton meter. |  |
| 2.18 | Describe the relationship between the weight of a body and the gravitational field strength. If the gravitational field that an object is in changes then its weight will change. | 1c |
| 2.19 | *Core Practical: Investigate the relationship between force, mass and acceleration by varying the masses added to trolleys. - Revise this from your practical book! As the trolley became heavier then it had a smaller acceleration with the same force.* | 1a, 1c,1d 2a, 2b, 2f  3a, 3b, 3c, 3d  4a, 4b, 4c, 4d |

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| **Students should:** | | **Maths skills** |
| 2.20 | **Explain that an object moving in a circular orbit at constant speed has a changing velocity.**  *- Direction is changing so velocity must be changing as velocity is linked to direction* | 5b |
| 2.21 | **Explain that for motion in a circle there must be a resultant force known as a centripetal force that acts towards the centre of the circle.**  *- If an object is changing velocity then a force must be involved.* | 5b |
| 2.22 | **Explain that inertial mass is a measure of how difficult it is to change the velocity of an object (including from rest) and know that it is defined as the ratio of force over acceleration.**  **Inertial mass (kg) = force (N)/ acceleration (m/s2)** | 1c, |
| 2.23 | Recall and apply Newton’s third law both to equilibrium situations and to collision interactions and relate it to the conservation of momentum in collisions.   * *The law says that when two objects interact the forces on each of them are equal and opposite)* * *Use the inertia and third law page on your revision guide for a bit of clarity.* | 1a, 1c, 1d 2a  3a, 3b, 3c, 3d |
| 2.24 | **Define momentum, recall and use the equation:**  **momentum (kilogram metre per second, kg m/s) = mass (kilogram, kg) × velocity (metre per second, m/s)**  ***p*** ***m*** ***v*** | 1a, 1c, 1d 2a  3a, 3b, 3c, 3d |
| 2.25 | **Describe examples of momentum in collisions. You may be asked to explain things like the movement of pool balls hitting each other or train carriages hitting each other. *Use the momentum page in your revision guide.*** | 1a, 1c, 1d 2a  3a, 3b, 3c, 3d |
| 2.26 | **Use Newton’s second law as:**  **force (newton, N) = change in momentum (kilogram metre per second, kg m/s) ÷ time (second, s)**  ***mv*** ***mu***  ***F***   ***t*** | 1a, 1c, 1d 2a  3a, 3b, 3c, 3d |
| 2.27 | Explain methods of measuring human reaction times and recall typical results. You could use a computer program or the ruler stick drop. | 2a, 2b, 2c, 2g |
| 2.28 | Recall that the stopping distance of a vehicle is made up of the sum of the thinking distance and the braking distance | 1a |
| 2.29 | Explain that the stopping distance of a vehicle is affected by a range of factors including:  a the mass of the vehicle.  b the speed of the vehicle   1. the driver’s reaction time 2. the state of the vehicle’s brakes e the state of the road   f the amount of friction between the tyre and the road surface  *More mass gives a larger stopping distance, more speed more distance, slower reactions more distance, bad brakes more distance, icy road or gravel on the road more distance, more friction gives less distance.* | 1c, 1d 2b, 2c, 2h 3b, 3c |

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| **Students should:** | **Maths skills** |
| 2.30 Describe the factors affecting a driver’s reaction time including drugs and distractions. Tiredness, alcohol, drugs and distractions like kids in the car all increase reaction time and increase stopping distance as thinking distance will go up. | 1d 2b, 2h  3c |
| 2.31 Explain the dangers caused by large decelerations and estimate the forces involved in typical situations on a public road.  *- If momentum changes very quickly like in a car crash that can give large forces on a person which can cause injury and death. Car crash forces can be into the several thousands of Newtons.* | 1c, 1d,  2c, 2h, 3b, 3c |
| 2.33P Carry out calculations on work done to show the dependence of braking distance for a vehicle on initial velocity squared (work done to bring a vehicle to rest equals its initial kinetic energy).  *- The kinetic energy a car has needs to be reduced when a car stops. The brakes need to do work that equals the kinetic energy. If a cars speed doubles then the work and distance needed to stop goes up by a factor of 4!* | 1c, 1d  2b, 2h 3b, 3c |

#### Topic 3 – Conservation of energy

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| **Students should:** | | **Maths skills** |
| 3.1 | **Recall** and use the equation to calculate the change in gravitational PE when an object is raised above the ground:  change in gravitational potential energy (joule, J) = mass (kilogram, kg) × gravitational field strength (newton per kilogram, N/kg) × change in vertical height (metre, m)  *GPE* *m* *g* *h* | 1a, 1c, 1d 2a  3a, 3b, 3c, 3d |
| 3.2 | **Recall** and use the equation to calculate the amounts of energy associated with a moving object:  *KE* 1 *m* *v* 2  2 | 1a, 1c, 1d 2a  3a, 3b, 3c, 3d |
| 3.3 | Draw and interpret diagrams to represent energy transfers.  Screen Clipping | 1c  2c |
| 3.4 | Explain what is meant by conservation of energy.  *Energy cannot be created or destroyed it is changed from one form to another by machines.* |  |
| 3.5 | Analyse the changes involved in the way energy is stored when a system changes, this means what are the starting energies and what energies are they transferred into. It’s on the transferring energy page of the rev guide.  a an object projected upwards or up a slope b a moving object hitting an obstacle  c an object being accelerated by a constant force d a vehicle slowing down  e bringing water to a boil in an electric kettle |  |
| 3.6 | Explain that where there are energy transfers in a closed system there is no net change to the total energy in that system**.**   * *i.e. Amount of energy at the start equals energy at the end.* |  |
| 3.7 | Explain that mechanical processes become wasteful when they cause a rise in temperature so dissipating energy in heating the surroundings.   * *Dissipate means to spread out.* |  |
| 3.8 | Explain, using examples, how in all system changes energy is dissipated so that it is stored in less useful ways.   * *e.g In a kettle electrical energy is transferred to the water (useful) but quite a lot heats the air and the material of the kettle. (spread out and wasted)* |  |
| 3.9 | Explain ways of reducing unwanted energy transfer including through lubrication, thermal insulation.   * *You would lubricate the moving parts of an engine to avoid friction wasting thermal energy. Also a heating system will be insulated to slow down unwanted heat loss.* |  |
| 3.10 | Describe the effects of the thickness and thermal conductivity of the walls of a building on its rate of cooling.   * *Thicker insulating materials will reduce the rate that heat is transferred and material with a low thermal conductivity will reduce the rate of heat transfer.* |  |
| 3.11 | **Recall and use the equation:**  useful energy transferred by the device  efficiency  total energy sup plied to the device   * *In other words, useful energy out divided by total energy into a machine.* | 1a, 1c, 1d 2a  3a, 3b, 3c, 3d |

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| **Students should:** | | **Maths skills** | |
| 3.12 | **Explain how efficiency can be increased. For a particular system describe how the waste energy can be reduced, thus improving the efficiency.** |  | |
| 3.13 | 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), and compare the ways in which both renewable and non-renewable sources are used.  - *Basically explain why renewables are used more and non-renewables are used less. Also what are the limitations of the renewables? Why aren’t they used all the time? It’s usually down to efficiency.* | 2c, | 2g |
| 3.14 | Explain patterns and trends in the use of energy resources.   * *More people = more electricity BUT appliances are becoming more efficient = using less electricity* * *Pressure from other countries and the public = government introduced targets for using renewables* * *Renewables - Protests over wind farm locations, Unreliable, Research into making them better = TIME and MONEY, Hybrid cars are more expensive than petrol cars* | 2c, | 2g |

#### Topic 4 – Waves

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| **Students should:** | | **Maths skills** |
| 4.1 | Recall that waves transfer energy and information without transferring matter |  |
| 4.2 | Describe evidence that with water and sound waves it is the wave and not the water or air itself that travels. |  |
| 4.3 | Define and use the terms frequency and wavelength as applied to waves.  *Frequency = number of cycles per second*  *Wavelength = the distance from one point of a wave to the next identical point.* |  |
| 4.4 | Use the terms amplitude, period, wave velocity and wavefront as applied to waves.  *Frequency =no. complete cycles passing a point each second Hz*  *Wavelength = length of a full cycle*  *Amplitude = displacement from rest to crest*  *Period = time taken for 1 cycle (1/f)*  *Wave velocity= speed of the wave*  *Wavefront –= front of the wave* |  |
| 4.5 | Describe the difference between longitudinal and transverse waves by referring to sound, electromagnetic, seismic and water waves. Sound is longitudinal, electromagnetic waves are transverse and seismic waves can be both. |  |
| 4.6 | Recall and use both the equations below for all waves:  wave speed (metre/second, m/s) = frequency (hertz, Hz)   wavelength (metre, m)  *v* *f* **  wave speed (metre/second, m/s) = distance (metre, m) ÷ time (second, s)  *v* *x t* | 1a, 1b, 1c, 1d 2a  3a, 3b, 3c, 3d |
| 4.7 | Describe how to measure the velocity of sound in air and ripples on water surfaces.  *How to measure speed of waves in* ***water:***  *speed = frequency x wavelength*  *Frequency = count no waves in 10 seconds THEN divide by 10*  *Wavelength = measured on frozen screen*  *How to measure speed of sound in* ***air:***  *speed = frequency (of signal generator) x wavelength (distance between microphone)*  *(of signal generator) x (distance between microphones)* | 2g |
| 4.10 | Explain how waves will be refracted at a boundary in terms of the change of direction and speed.   * *If a wave enters a more dense material at an angle then one edge of the wavefront hits the dense material first and is slowed down, this throws the wave off course.* | 1c 3c  5b |
| 4.11 | **Recall that different substances may absorb, transmit, refract or reflect waves in ways that vary with wavelength.**  *Reflection – wave sent back*  *Refraction – wave changes direction*  *Transmitted – wave travels through*  *Absorbed – wave transfer energy to material* |  |

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| **Students should:** | **Maths skills** |
| 4.17 *Core Practical: Investigate the suitability of equipment to measure the speed, frequency and wavelength of a wave in a solid and a fluid*  *How to measure speed of waves in* ***water (fluid):***  *speed = frequency x wavelength*  *Frequency = count no waves in 10 seconds THEN divide by 10*  *Wavelength = measured on frozen screen*  *How to measure speed of sound in* ***solids:***  *speed = frequency x wavelength*  *Frequency = computer*  *Wavelength = 2 x rod length* | 2g |

#### Topic 5 – Light and the electromagnetic spectrum

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| **Students should:** | **Maths skills** |
| 5.7 Recall that all electromagnetic waves are transverse, that they travel at the same speed in a vacuum |  |
| 5.8 Explain, with examples, that all electromagnetic waves transfer energy from source to observer.  *- Infra red transfers heat etc.* |  |
| 5.9 *Investigate refraction in rectangular glass blocks in terms of the interaction of electromagnetic waves with matter* |  |
| 5.10 Recall the main groupings of the continuous electromagnetic spectrum including (in order) radio waves, microwaves, infrared, visible (including the colours of the visible spectrum), ultraviolet, x-rays and gamma rays |  |
| 5.11 Describe the electromagnetic spectrum as continuous from radio waves to gamma rays and that the radiations within it can be grouped in order of decreasing wavelength and increasing frequency.  ***-*** *Gamma is high frequency and low wavelength and radio waves are the opposite.* | 1a, 1c 3c |
| 5.12 Recall that our eyes can only detect a limited range of frequencies of electromagnetic radiation.  *Ie. The visible spectrum part of the electromagnetic spectrum.* |  |
| 5.13 **Recall that different substances may absorb, transmit, refract or reflect electromagnetic waves in ways that vary with wavelength** |  |
| 5.14 Explain the effects of differences in the velocities of electromagnetic waves in different substances | 1a, 1c  3c |
| 5.20 Recall that the potential danger associated with an electromagnetic wave increases with increasing frequency. *Gamma (highest frequency) is the most dangerous for example. Causes cancer.* |  |
| 5.21 Describe the harmful effects on people of excessive exposure to electromagnetic radiation, including:  a microwaves: internal heating of body cells b infrared: skin burns   1. ultraviolet: damage to surface cells and eyes, leading to skin cancer and eye conditions 2. x-rays and gamma rays: mutation or damage to cells in the body |  |
| * 1. Describe some uses of electromagnetic radiation      1. radio waves: including broadcasting, communications and satellite transmissions      2. microwaves: including cooking, communications and satellite transmissions      3. infrared: including cooking, thermal imaging, short range communications, optical fibres, television remote controls and security systems      4. visible light: including vision, photography and illumination      5. ultraviolet: including security marking, fluorescent lamps, detecting forged bank notes and disinfecting water      6. x-rays: including observing the internal structure of objects, airport security scanners and medical x-rays      7. gamma rays: including sterilising food and medical equipment, and the detection of cancer and its treatment |  |
| 5.23 Recall that radio waves can be produced by, or can themselves induce, oscillations in electrical circuits. **- -** *Induce means create.* |  |
| 5.24 Recall that changes in atoms and nuclei can  a generate radiations over a wide frequency range b be caused by absorption of a range of radiations   * *Changes could be absorbing light or emitting light or heat, emitting or absorbing particles.* |  |

#### Topic 6 – Radioactivity

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| **Students should:** | | **Maths skills** |
| 6.1 | Describe an atom as a positively charged nucleus, consisting of protons and neutrons, 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 | 5b |
| 6.2 | Recall the typical size (order of magnitude) of atoms and small molecules.   * *Atoms approx. 10-10m* |  |
| 6.3 | Describe the structure of nuclei of isotopes using the terms atomic (proton) number and mass (nucleon) number and using symbols in the format 13 C | 1a 3a |
| 6.4 | Recall that the nucleus of each element has a characteristic positive charge, but that isotopes of an element differ in mass by having different numbers of neutrons | 2g 5b |
| 6.5 | Recall the relative masses and relative electric charges of protons (1,+1), neutrons (1,0), electrons (virtually 0,-1) and positrons (virtually zero and +1) |  |
| 6.6 | Recall that in an atom the number of protons equals the number of electrons and is therefore neutral |  |
| 6.7 | Recall that in each atom its electrons orbit the nucleus at different set distances from the nucleus,these are called shells or orbits | 5b |
| 6.8 | Explain that electrons change orbit when there is absorption or emission of electromagnetic radiation.   * *Absorbing energy makes electrons go up levels.* | 5b |
| 6.9 | Explain how atoms may form positive ions by losing outer electrons. | 5b |
| 6.10 | Recall that alpha, β– (beta minus), β+ (positron), gamma rays and neutron radiation are emitted from unstable nuclei in a random process |  |
| 6.11 | Recall that alpha, β– (beta minus), β+ (positron) and gamma  rays are ionising radiations.  *Ionising means to knock electrons completely out of the shell.* |  |
| 6.12 | Explain what is meant by background radiation.  *This is radiation all around us in the atmosphere, eg from rocks, the sun or nuclear testing etc.* |  |
| 6.13 | Describe the origins of background radiation from Earth and space |  |
| 6.14 | Describe methods for measuring and detecting radioactivity limited to photographic film and a Geiger–Müller tube.  *Radiation blackens a photo film, radiation ionizes the air inside a GM tube causing a small current to flow that can be counted.* |  |
| 6.15 | Recall that an alpha particle is equivalent to a helium nucleus (*eg 2 protons and 2 neutrons*), a beta particle is an electron emitted from the nucleus (*a neutron splits into a proton and an electron*) and a gamma ray is electromagnetic radiation |  |
| 6.16 | Compare alpha, beta and gamma radiations in terms of their abilities to penetrate and ionize.   * *Which is most penetrating etc and which is most ionizing etc.* |  |

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| **Students should:** | **Maths skills** |
| 6.17 Describe how and why the atomic model has changed over time including reference to the plum pudding model and Rutherford alpha particle scattering leading to the Bohr model.  *- Check the revision guide for the models of the atoms.* | 5b |
| 6.18 Describe the process of β– decay Atomic number goes up by one but the mass number stays the same.  *- a neutron becomes a proton plus an electron* | 1b, 1c,  3c |
| 6.19 Describe the process of β+ decay **t**he atomic number goes down by one but the mass number stays the same.  *- a proton becomes a neutron plus a positron* | 1b, 1c,  3c |
| 6.20 Explain the effects on the atomic (proton) number and mass (nucleon) number of radioactive decays (α, β, γ and neutron emission) | 1b, 1c, 3c |
| 6.21 Recall that nuclei that have undergone radioactive decay often undergo nuclear rearrangement with a loss of energy as gamma radiation |  |
| 6.22 Use given data to balance nuclear equations in terms of mass and charge  *- see 6.18 and 6.;19. Also if alpha is emitted the mass goes down by 4 and the atomic number goes down by 2* | 1b, 1c,  3c |
| 6.23 Describe how the activity of a radioactive source decreases over a period of time.  *- Decreases rapidly at first then the rate slows. Learn the shape of the graph.* | 2g  4c |
| 6.24 Recall that the unit of activity of a radioactive isotope is the Becquerel, Bq |  |
| 6.25 Explain that the half-life of a radioactive isotope is the time taken for half the undecayed nuclei to decay or the activity of a source to decay by half | 1c, 1d 2a |
| 6.26 Explain that it cannot be predicted when a particular nucleus will decay but half-life enables the activity of a very large number of nuclei to be predicted during the decay process | 1c, 3d |
| 6.27 Use the concept of half-life to carry out simple calculations on the decay of a radioactive isotope, including graphical representations | 1a, 1b, 1c, 1d 2a, 2g  3a, 3b, 3c, 3d |
| 6.29 Describe the dangers of ionising radiation in terms of tissue damage and possible mutations and relate this to the precautions needed.  *- E.g. radiation can ionize the cells in the body. DNA can be damaged and cells can multiply out of control. CANCER. Precautions, lead shields, limiting x rays etc* |  |

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| **Students should:** | **Maths skills** |
| 6.31 Explain the precautions taken to ensure the safety of people exposed to radiation, including limiting the dose for patients and the risks to medical personnel(radiation badges and shields for x rays etc |  |
| 6.32 Describe the differences between contamination and irradiation effects and compare the hazards associated with these two.  *- contamination - radioactive substances on you or in you and*  *- irradiation - emissions from a radioactive source directed at you* |  |