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CLASS 10 PHYSICS NOTES
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Chapter 10 : THERMAL PHYSICS

Short Answer Questions

10.1 What factors influence the thermal expansion of solids?

Thermal expansion in solids depends on three main factors: the original dimension (length, area, or volume) of the solid, the change in temperature (ΔT), and the nature of the material (represented by its coefficient of expansion α or β).

10.2 What is latent heat of fusion?

Latent heat of fusion is the amount of heat energy required to change a unit mass of a substance from the solid state to the liquid state at its melting point without any change in temperature. It is given by $H_f = \frac{\Delta Q_f}{m}$.

10.3 How do different materials exhibit varying thermal expansion behaviors?

Different materials have distinct atomic structures and bond strengths. Materials with weaker intermolecular bonds expand more upon heating, while those with stronger atomic bonds resist expansion, leading to different coefficients of thermal expansion.

10.4 How does evaporation contribute to cooling processes in everyday life?

During evaporation, high-energy molecules escape from the surface of a liquid, leaving behind molecules with lower average kinetic energy. This lowers the temperature of the remaining liquid, causing a cooling effect used in processes like sweating and earthen pot cooling.

10.5 What is latent heat of vaporization, and how is it calculated?

Latent heat of vaporization is the quantity of heat required to convert a unit mass of a liquid into gas at its boiling point without a temperature rise. It is calculated using the formula $H_v = \frac{\Delta Q_v}{m}$, where ΔQ_v is heat supplied and m is mass.

Constructed Response Questions

10.1 Why do bridges need expansion joints but glass jars with metal lids do not, even though both experience temperature changes? Discuss in terms of the nature of thermal expansion. Bridges span large distances, so thermal expansion produces significant physical length changes that can cause structural buckling without expansion joints. Glass jars and metal lids are small, so the absolute expansion is tiny; moreover, the metal lid expands slightly more than the glass jar, helping loosen it rather than causing structural damage.

10.2 If two liquids are heated under same conditions, but one of them heats up faster, what does this indicate about the specific heat capacity?

The liquid that heats up faster has a lower specific heat capacity ($c = \frac{Q}{m\Delta T}$). A lower specific heat capacity means the substance requires less thermal energy to produce a given rise in temperature.

10.3 Why does a liquid evaporate faster when the air is dry?

Dry air has a low concentration of water vapor (low humidity), which creates a steeper concentration gradient between the liquid surface and the surrounding air. This reduces the rate of condensation back into the liquid, allowing net evaporation to proceed much faster.

10.4 When a piece of ice melts, the temperature does not increase even though heat is supplied. Where does the energy go, and why is this important in phase change?

The supplied thermal energy is used to break the intermolecular hydrogen bonds in the crystal lattice of ice rather than increasing kinetic energy. This energy absorption without temperature change is essential for phase change, allowing the substance to transform completely from solid to liquid at a fixed melting point.

10.5 Why do electric transmission wires sag in summer and tighten in winter?

In summer, high atmospheric temperatures cause thermal expansion in metallic transmission wires, increasing their length and causing them to sag. In winter, the drop in temperature causes thermal contraction, making the wires shorten and tighten.

Comprehensive Questions

10.1 How does thermal expansion differ between solids, liquids, and gases? Provide examples to illustrate these differences.

Solids expand the least due to strong intermolecular forces (e.g., railway tracks expanding in summer). Liquids expand more than solids because of weaker intermolecular bonds (e.g., mercury rising in a thermometer). Gases expand the most upon heating as their particles are nearly free (e.g., a heated hot-air balloon expanding).

10.2 What are some practical consequences of thermal expansion in everyday life, such as in construction materials or household appliances?

In construction, gaps are left between railway tracks and concrete road slabs to prevent buckling during heat expansion. In household appliances, bimetallic strips bend upon heating to act as automatic thermal switches in electric irons and thermostats.

10.3 What is latent heat, and why is it important in phase transitions like melting and vaporization?

Latent heat is energy absorbed or released by a substance during a change of physical state without changing its temperature. It is critical because it powers structural rearrangement—overcoming intermolecular attractive forces during melting and completely breaking them during vaporization.

10.4 Why do solids, liquids, and gases expand when heated? Explain with examples.

Heating increases the average kinetic energy of molecules, causing them to vibrate or move more vigorously and push further apart. Examples include expanding steel beams in bridges (solids), rising liquid in thermometers (liquids), and expanding air inside a warmed bicycle tire (gases).

10.5 If we have an equal amount of water in a wide, shallow dish and a tall, narrow container kept at the same temperature, in which container will evaporation occur faster? Explain the reason scientifically.

Evaporation occurs faster in the wide, shallow dish. Evaporation is a surface phenomenon, and the shallow dish offers a much larger surface area, allowing a greater number of high-energy water molecules to escape into the air simultaneously.

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Chapter 11 : TRANSFER OF THERMAL ENERGY

Short Answer Questions

11.1 What are the three primary types of heat transfer?

The three primary types of heat transfer are conduction, convection, and radiation. Conduction occurs through direct particle contact, convection through mass movement of fluids, and radiation via electromagnetic waves without needing a medium.

11.2 Why does heat travel faster in metals compared to non-metals?

Metals possess a high density of free electrons alongside lattice vibrations. These free electrons move rapidly through the metallic lattice, transferring kinetic energy much faster than the slow atom-to-atom vibrations found in non-metals.

11.3 How does convection transfer heat in liquids and gases?

When a fluid is heated, its molecules expand, becoming less dense and rising. The cooler, denser fluid sinks to take its place, creating a continuous circulating movement called a convection current that distributes heat throughout the fluid.

11.4 What natural phenomenon causes land and sea breezes?

Land and sea breezes are caused by the unequal heating and cooling rates of land and water (convection currents). Land heats up and cools down faster than water due to its lower specific heat capacity, driving localized wind patterns.

11.5 How do birds and gliders take advantage of convection currents?

Birds and gliders utilize thermals, which are rising columns of warm air generated by ground heating. By circling within these rising convection currents, they gain altitude and stay afloat for long periods without expending energy.

11.6 What is radiation, and how does it transfer heat?

Radiation is the transfer of heat energy through electromagnetic waves (mainly infrared radiation). Unlike conduction and convection, radiation does not require any material medium and can travel through a vacuum, such as sunlight reaching Earth.

11.7 Why does a dull black surface emit and absorb more radiation than a shiny silver surface?

A dull black surface is an ideal absorber and radiator because it reflects minimal electromagnetic radiation, absorbing nearly all incident energy. Conversely, a shiny silver surface reflects most radiation, making it a poor absorber and emitter.

11.8 How does the greenhouse effect help regulate Earth's temperature?

Greenhouse gases (like CO_2 and water vapor) trap outgoing infrared radiation emitted by the Earth's surface rather than letting it escape into space. This maintains a warm average atmospheric temperature suitable for supporting life.

Constructed Response Questions

11.1 During the Leslie's Cube experiment, why does the dull black surface radiate more heat than the shiny silver one, even though they are at the same temperature?

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Thermal radiation emission depends on emissivity alongside temperature. The dull black surface has a high emissivity close to 1, allowing efficient thermal emission, whereas the shiny silver surface has low emissivity because it acts as a strong reflector.

11.2 How does the size (surface area) of a radiator affect the amount of heat it emits through radiation? Explain using a real-world example.

The rate of heat emission is directly proportional to surface area ($Q/t \propto A$). A larger surface area provides more space for thermal energy to radiate out, which is why car radiators use thin metal fins to maximize area and cool the engine rapidly.

11.3 Why is convection not possible in solids, and how do convection currents in liquids and gases compensate for their poor thermal conductivity?

Convection requires fluid flow, which is impossible in solids because their particles are locked in fixed positions. In fluids, bulk mass movement rapidly transports thermal energy across large distances, overcoming their poor lattice conduction.

11.4 How do birds like eagles and gliders manage to stay aloft without flapping their wings for hours? Explain the scientific principle involved.

They exploit buoyant thermal updrafts created by surface convection. As warm air rises from sun-heated ground, its upward velocity counteracts gravity, allowing eagles and gliders to stay aloft by continuously gliding within these rising air columns.

11.5 Why does a hot metal object placed in a cooler room eventually cool down? Explain using the concepts of radiation and thermal equilibrium.

The hot object emits infrared radiation at a higher rate than it absorbs from the cooler surroundings. It continues losing net heat until its temperature equals the room's temperature, reaching thermal equilibrium where emission equals absorption.

Comprehensive Questions

11.1 Describe how convection occurs in fluids. How do convection currents contribute to natural phenomena such as sea breezes and wind patterns?

Heating a fluid decreases its density, causing it to rise while cooler, denser fluid sinks, forming a continuous convection cycle. During daytime, land warms faster than the ocean, making hot air above land rise and cool sea air blow inland as a sea breeze; large-scale solar heating drives global wind patterns similarly.

11.2 How does radiation differ from conduction and convection in terms of heat transfer? Give examples of radiation in everyday life and explain how different surfaces affect radiation absorption and emission.

Radiation transfers energy via electromagnetic waves without requiring a physical medium, unlike conduction and convection. Everyday examples include warmth felt near a fire or sunlight. Dark, rough surfaces maximize absorption and emission, while light, polished surfaces reflect radiation.

11.3 Discuss the role of the greenhouse effect in regulating Earth's temperature. What are the potential consequences of an enhanced greenhouse effect due to human activities?

The natural greenhouse effect traps thermal radiation to keep Earth warm enough for life. However, excessive human emissions of gases like CO2 amplify heat retention, causing global warming, melting polar ice caps, rising sea levels, and severe climate disruptions.

11.4 Compare the absorption and emission of heat by different surfaces. How does the colour and texture of a surface affect its ability to absorb and emit heat?

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Color and texture dictate radiation performance: dark and rough surfaces act as excellent absorbers and emitters because they absorb most incoming radiation. Light-colored and polished surfaces act as good reflectors, absorbing and emitting very little thermal radiation.

11.5 Analyze how uneven heating of Earth's surface leads to the formation of convection currents and influence wind patterns.

The equator receives direct sunlight while the poles receive indirect rays, creating strong thermal gradients. Hot equatorial air expands and rises toward the poles, while cold polar air moves downward toward the equator, creating global atmospheric convection cells that shape worldwide wind systems.

Chapter 12: WAVES

Short Answer Questions

12.1 What do waves transfer from one place to another?

Waves transfer energy and momentum from one place to another through a medium or space. Importantly, they do so without causing any permanent displacement or net transfer of matter.

12.2 Name any two examples of mechanical waves.

Two common examples of mechanical waves are sound waves traveling through air and water waves on the surface of a pond. Both require a material medium to propagate.

12.3 Which type of wave can travel through vacuum?

Electromagnetic waves (such as light waves, radio waves, and X-rays) can travel through a vacuum. They do not require a material medium because they consist of oscillating electric and magnetic fields.

12.4 What is the difference between transverse and longitudinal waves?

In transverse waves, medium particles vibrate perpendicular to the direction of wave propagation (e.g., light). In longitudinal waves, particles vibrate parallel to the direction of wave propagation, forming compressions and rarefactions (e.g., sound).

12.5 What is meant by wavelength?

Wavelength (λ) is the distance between two consecutive points in phase on a wave, such as two consecutive crests/troughs in transverse waves or two consecutive compressions/rarefactions in longitudinal waves.

12.6 Write the definition of frequency. Frequency (f) is defined as the number of complete wave cycles or oscillations passing a fixed point per second. It is measured in Hertz (Hz), where 1 Hz=1 cycle/second.

12.7 What causes a tsunami in the ocean?

A tsunami is caused by large-scale underwater disturbances that rapidly displace huge volumes of water. Common triggers include undersea earthquakes, volcanic eruptions, coastal landslides, or underwater explosions.

Constructed Response Questions

12.1 Why sound cannot travel through space, but light can? Explain using the concept of wave types.

Sound is a mechanical wave that relies on particle collisions in a physical medium to propagate energy. Outer space is a vacuum, so sound cannot travel through it, whereas light is an electromagnetic wave consisting of self-propagating electric and magnetic fields that require no material medium.

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12.2 A student shakes one end of a rope and observes waves move along it. What kind of wave is this, and how do the particles move?

This is a transverse mechanical wave. As the disturbance travels horizontally along the length of the rope, individual rope particles move vertically up and down, vibrating perpendicular to the wave's direction of motion.

12.3 How does the amplitude of a wave relate to the energy it carries? Give an example to support your answer.
The energy (E) carried by a wave is directly proportional to the square of its amplitude ($E \propto A2$). For example, ocean waves with larger crest heights (higher amplitude) carry significantly more energy and hit shores with much greater force than small ripples.

12.4 Why do we still hear a person talking even if he is behind a wall? Explain using the concept of diffraction.
Sound waves have relatively long wavelengths (from a few centimeters to meters) that are comparable to the size of doorways and wall edges. This enables sound waves to easily diffract—or bend around obstacles—and reach our ears even when direct line-of-sight is blocked.

12.5 If size of slit, a wave passes through is much smaller than the wavelength, what will happen to the wave after passing through the slit? Explain briefly.

If the slit width is much smaller than the wavelength ($d \ll \lambda$), maximum diffraction occurs. The wave bends significantly as it passes through, spreading outward uniformly in all directions and behaving almost like a point source emitting spherical or circular wave fronts.

Comprehensive Questions

12.1 Explain how waves transfer energy without transferring matter. Give examples from daily life.

Waves transport energy through traveling disturbances while medium particles only oscillate locally around fixed equilibrium positions. For example, a leaf floating on water moves up and down as a surface wave passes underneath, but it is not carried forward along with the energy of the wave.

12.2 Describe the difference between mechanical and electromagnetic waves with suitable examples.

Mechanical waves require a physical medium (solid, liquid, or gas) to propagate, such as sound waves or seismic waves. Electromagnetic waves can travel through both matter and a vacuum because they consist of oscillating electric and magnetic fields, such as light, microwaves, and radio waves.

12.3 What are transverse and longitudinal waves? Explain each with the help of diagrams and examples.

In transverse waves, particle motion is perpendicular to wave propagation (forming alternating crests and troughs, as seen in light or plucked guitar strings). In longitudinal waves, particle motion is parallel to wave propagation (forming compressions and rarefactions, as seen in sound waves traveling through air).

12.4 Discuss the properties of waves; such as reflection, refraction, and diffraction. Support your answer with examples.

Reflection occurs when a wave bounces off a boundary back into its original medium (e.g., an echo). Refraction is the bending of a wave as it changes speed when passing between media (e.g., ocean waves bending near a shore). Diffraction is the spreading of waves around obstacles or through narrow gaps (e.g., hearing sound through an open door).

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Chapter 13 : SOUND

Short Answer Questions

13.1 How does the medium affect the speed of sound?

The speed of sound depends on the density and elasticity of the medium. Sound travels fastest in solids, slower in liquids, and slowest in gases because particles are closer together and transmit mechanical vibrations more efficiently in dense, elastic media.

13.2 Does sound waves show reflection?

Yes, sound waves undergo reflection when they hit a hard surface like a wall, mountain, or cliff. The reflected sound follows the laws of reflection, where the angle of incidence equals the angle of reflection.

13.3 What factors influence the loudness of sound?

Loudness depends on the amplitude of the vibrating body, the surface area of the vibrating object, the distance of the listener from the source, and the physical sensitivity of the listener's ears.

13.4 Why do we hear an echo when we clap near a building?

When a sound wave hits a hard vertical surface like a building wall, it reflects back toward the source. If the reflected sound reaches the human ear after 0.1 seconds, the brain perceives it as a distinct repeating sound called an echo.

13.5 What is ultrasound, how is it used in medicine?

Ultrasound consists of sound waves with frequencies higher than 20 kHz (above human hearing limits). In medicine, it is used for non-invasive diagnostic imaging (e.g., monitoring fetal growth) and therapeutic treatments like breaking kidney stones.

Constructed Response Questions

13.1 Why does a tuning fork placed on a wooden table produce a louder sound than when held in the air? What does this tell us about the role of surface area in sound propagation?

Placing the vibrating tuning fork on a wooden table forces a much larger surface area of wood to vibrate simultaneously. This sets a larger volume of surrounding air molecules into motion, proving that an increase in vibrating surface area leads to greater amplitude and louder sound output.

13.2 If sound needs a medium to travel, how does the bell jar experiment prove this requirement? What happens when air is removed, and why?

In a bell jar experiment, an electric bell is rung inside a sealed jar. As air is continuously pumped out using a vacuum pump, the ringing sound gradually fades until it vanishes completely, proving that sound waves cannot travel through a vacuum without a material medium.

13.3 A person hears his echo when shouting near a tall building. Why must the building be at least 17 metres away for the echo to be heard clearly?

The human brain retains a sound sensation for about 0.1 seconds (persistence of hearing). Since sound travels at approximately 340 m/s, the round-trip distance must be at least $340 \times 0.1 = 34$ meters, making the minimum distance to the reflecting wall 17 meters.

13.4 Why do voices of men sound deeper than those of women or children, even when they are speaking at the same intensity? Explain using the relationship between frequency and pitch.

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Men have longer and thicker vocal cords that vibrate at a lower frequency, whereas women and children have shorter, thinner vocal cords that vibrate at higher frequencies. Pitch is directly proportional to frequency, so lower frequencies produce a deeper (lower-pitched) voice.

13.5 In what ways do soft materials like carpets or curtains improve the acoustics of a room? How do they affect echoes and sound quality?

Soft, porous materials like carpets and curtains absorb sound energy instead of reflecting it. By preventing multiple reflections and echoes (reverberations), they reduce unwanted noise and improve overall clarity and sound quality inside a room.

13.6 When a person claps near a canyon and hears the echo after a few seconds, how can they calculate the distance to the canyon? What principle is used in this method?

The distance is calculated using $d=2v\times t$, where v is the speed of sound and t is the total echo time. This method relies on the principle of sound reflection (echolocation), halving the total distance covered by the round-trip sound wave.

Comprehensive Questions

13.1 What is the approximate speed of sound in air, and what factors affect it?

The speed of sound in dry air at 0∘C is approximately 331 m/s (around 343 m/s at 20∘C). It is affected by temperature (increases with rising temperature), humidity (increases in moist air), and the physical state/density of the medium.

13.2 Why does sound travel faster in solids than in liquids and gases? Explain.

Solids have higher elastic moduli and tightly packed atoms compared to liquids and gases. When a particle in a solid vibrates, its strong atomic bonds transfer mechanical energy rapidly to neighboring particles, enabling much faster wave propagation.

13.3 How do amplitude and frequency, affect the quality of sound? Explain.

Amplitude determines the intensity and loudness of a sound (larger amplitude produces louder sound), while frequency determines its pitch (higher frequency produces higher pitch). Together with timber (waveform shape), they dictate the overall clarity and perception of sound.

13.4 How does echo occur? Explain.

An echo occurs when a sound wave meets a distant, rigid obstacle and reflects back to the listener. If the time delay between the original sound and its reflection is greater than 0.1 seconds, the human ear hears the reflected sound as a separate, distinct sound.

13.5 How do reflection, refraction, and diffraction affect the behaviour of sound waves?

Reflection causes echoes by bouncing sound off barriers; refraction bends sound waves when passing through air layers of varying temperatures/densities; and diffraction allows sound waves to bend around corners or through openings, spreading sound into shaded regions.

13.6 What are infrasound and ultrasound, and how are they used in different applications?

Infrasound consists of frequencies below 20 Hz (used in monitoring earthquakes and animal communication), while ultrasound consists of frequencies above 20 kHz (used in medical imaging, cleaning delicate instruments, and industrial flaw detection).

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Chapter 14 : LIGHT

B. Short Answer Questions

14.1 What happens when light passes from air to water?

When light enters water from air, it slows down because water is an optically denser medium. This reduction in speed causes the light ray to refract (bend) toward the normal line at the boundary.

14.2 Define refractive index. What is the refractive index of air and water?

Refractive index (n) is the ratio of the speed of light in a vacuum (c) to its speed in a given medium (v), given by n=vc. The refractive index of air is approximately 1.00 (1.0003), and for water, it is 1.33.

14.3 What is the principle behind optical fibres?

The working principle behind optical fibres is continuous total internal reflection. Light signals entering the core strike the inner cladding interface at an angle greater than the critical angle, trapping light inside to transmit signals over long distances with minimal loss.

14.4 Describe briefly how a convex lens forms a real or virtual image.

A convex lens forms a real, inverted image when the object is placed beyond its principal focus (p>f), as light rays physically converge. It forms a virtual, upright image when the object is placed closer than the focal length (p<f).

14.5 How does the power of a lens relate to its focal length?

The power of a lens (P) is inversely proportional to its focal length (f) measured in meters (P=f1). It is expressed in diopters (D), where a shorter focal length results in a higher optical power.

14.6 Write Snell's law and define the terms used in the equation.

Snell's law is given by n1sin(i)=n2sin(r), or n=sin(r)sin(i) for light entering from air. Here, n is the refractive index, i is the angle of incidence, and r is the angle of refraction.

C. Constructed Response Questions

14.1 When a pencil is partially dipped in water, it appears bent or broken. What principle of light explains this phenomenon, and how does it relate to changes in speed?

This phenomenon is caused by light refraction. Light reflected from the submerged part of the pencil speeds up and bends away from the normal upon leaving water into air, making the submerged pencil appear shifted relative to its real position.

14.2 Why can a prism separate white light into its component colours while a plane glass slab cannot, even though both cause refraction?

A prism has non-parallel refracting faces, so different wavelengths (colors) bend at different angles and diverge permanently (dispersion). In a plane glass slab with parallel faces, the secondary refraction at the second surface cancels out the initial dispersion, recombining the colors into parallel exiting rays.

14.3 Why does light undergo total internal reflection when travelling from water to air at a certain angle but not the other way around?

Total internal reflection requires light to travel from a denser medium to a rarer medium so that the refracted ray bends *away* from the normal. When light travels from air to water (rarer to denser), it bends *toward* the normal, making an angle of refraction of 90∘ impossible.

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14.4 Optical fibres use total internal reflection for signal transmission. What would happen if the cladding had a higher refractive index than the core, and why?

If the cladding had a higher refractive index than the core, total internal reflection would fail completely. Light would refract out of the core into the cladding instead of staying confined, causing total loss of the transmitted optical signal.

14.5 A person uses a magnifying glass to read small print. What must be the relationship between the object distance and the focal length of the lens for the image to be upright and magnified?

The object distance (p) must be strictly less than the focal length (f) of the convex lens ($p<f$). This placement forces the lens to project a magnified, upright, and virtual image on the same side as the object.

D. Comprehensive Questions

14.1 Explain the terms; normal, angle of incidence and angle of reflection in the context of light reflection. Provide a diagram to illustrate these terms.

The *normal* is an imaginary line perpendicular to the reflecting surface at the point of impact. The *angle of incidence* (i) is the angle between the incident light ray and the normal, while the *angle of reflection* (r) is the angle between the reflected ray and the normal.

14.2 Define the terms critical angle and total internal reflection. Explain the conditions required for total internal reflection to occur.

The *critical angle* (C) is the angle of incidence in a denser medium for which the angle of refraction in the rarer medium is 90∘. *Total internal reflection* occurs when light traveling from a denser to a rarer medium strikes the boundary at an angle of incidence greater than C, causing 100% of the light to reflect back inside.

14.3 Derive the equation; (n=1/sinC) for the refractive index in terms of the critical angle C. Include all steps and assumptions.

By Snell's law, $n_1\sin(\theta_1)=n_2\sin(\theta_2)$. Assuming medium 1 is dense ($n_1=n$) and medium 2 is air ($n_2=1$), set the incident angle $\theta_1=C$ and refraction angle $\theta_2=90^\circ$. Substituting gives $n\sin(C)=1\cdot\sin(90^\circ)$, which simplifies directly to $n=\sin C1$.

14.4 Describe the structure of an optical fibre. Write its any two advantages.

An optical fibre consists of a central glass/plastic *core* with a high refractive index surrounded by a protective *cladding* layer of lower refractive index. Two major advantages are its capability to transmit massive data bandwidth at near-light speed and its total immunity to electromagnetic interference.

14.5 What is long-sightedness? Discuss its causes.

Long-sightedness (hyperopia) is a vision defect where a person can clearly see distant objects but struggles to focus on nearby objects. It is caused either by an eye lens that is too flat (insufficient converging power) or an eyeball that is physically too short along its optical axis.

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Chapter 15: ELCTROSTATICS

Short Answer Questions

15.1 State Coulomb's law of electrostatics and write its mathematical form.

Coulomb's law states that the electrostatic force of attraction or repulsion between two stationary point charges is directly proportional to the product of their charges and inversely proportional to the square of the distance between them. Its formula is

$$F = k\frac{|q_1 q_2|}{r^2}.$$

15.2 What is an electric field?

An electric field is the region or space around an electric charge in which another charge experiences an electrostatic force. It is represented mathematically by field strength .

$$\vec{E} = \frac{F}{q_0}.$$

15.3 Give two examples each of electrical conductors and electrical insulators.

Two examples of electrical conductors are copper and aluminum, which allow charges to flow easily. Two examples of electrical insulators are rubber and glass, which strongly resist the flow of electric charges.

15.4 List some applications of electrostatics in daily life.

Applications of electrostatics include electrostatic paint spraying on automobiles, the functioning of laser printers and photocopiers, and electrostatic precipitators used to clean industrial smoke.

15.5 What happens when like charges and unlike charges are brought close to each other?

When like charges (such as positive and positive, or negative and negative) are brought close together, they repel each other. When unlike charges (positive and negative) are brought close together, they attract each other.

15.6 What is meant by electrical breakdown, and when does it occur?

Electrical breakdown occurs when an insulating material (like air) is subjected to an extremely high electric field, causing it to ionize and suddenly become conductive. This results in a sudden discharge, such as a spark or lightning strike.

15.7 What are the dangers of static electricity?

Static electricity can cause sudden electrical shocks to humans and ignite flammable gases or fuel vapors, leading to explosions in chemical plants or refueling stations. It can also damage sensitive microelectronic components.

C. Constructed Response Questions

15.1 Why do some materials gain electrons while others lose electrons when rubbed together? What property of the materials determines this behavior?

Different materials have varying electron affinities and work functions (the energy required to detach an electron). When two materials are rubbed, the material with lower electron affinity loses electrons easily, while the one with higher electron affinity gains them.

15.2 A charged comb attracts small pieces of paper, but after some time, the paper pieces fall off. Why does this happen?

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The comb initially induces an opposite charge on neutral paper pieces, attracting them. Once the paper touches the comb, charge transfers to the paper by conduction, giving them the same charge sign, which causes mutual repulsion and makes the paper fall off.

15.3 Why do dust particles often get attracted to television screens or computer monitors after they are turned ON?

When turned on, the screen accumulates a high electrostatic charge due to electron beams or internal high voltages. This charged surface induces opposite charges on nearby floating dust particles, pulling them toward the screen by electrostatic attraction.

15.4 If we rub a balloon on our dry hair and place it near a thin stream of water, the water bends toward the balloon. What does this tell us about the Nature of water molecules?

This indicates that water molecules are polar (having distinct positive and negative ends). The static charge on the balloon attracts the oppositely charged poles of the water molecules, causing the continuous stream of water to bend toward the balloon.

15.5 A conductor and an insulator are both placed in an electric field. How will their behavior differ, and why?
In a conductor, free electrons migrate rapidly across the surface to oppose the field, completely shielding its interior. In an insulator, tightly bound electrons cannot move freely; instead, their molecular electron clouds polarize, slightly weakening the internal electric field.

D. Comprehensive Questions

15.1 Discuss the working of a gold leaf electroscope. How can it be used to determine the nature and magnitude of charge on a body?

A gold leaf electroscope works on electrostatic repulsion: when a charge is transferred to its brass rod, the thin gold leaves gain identical charges and diverge. The degree of divergence indicates charge magnitude, while testing with a known charge reveals whether the charge is positive or negative.

15.2 How does Coulomb's law help in understanding the interaction between charged particles? What factors affect the force between them?

Coulomb's law provides the quantitative basis for calculating electrostatic forces between charged particles. The magnitude of this force is determined by three main factors: the quantity of the charges (q1,q2), the separation distance (r), and the dielectric permittivity of the surrounding medium.

15.3 Explain the concept of electric field intensity

y. How can the electric field of a point charge and a parallel plate capacitor be represented using field lines?
Electric field intensity (E=qF) measures the force per unit positive test charge. Field lines for a single point charge radiate radially outward (if positive) or inward (if negative), whereas a parallel plate capacitor produces uniform, evenly spaced parallel lines directed from the positive to negative plate.

15.4 Explain how and why electrical conductors and insulators behave differently in terms of charge transfer and movement of electrons.

Conductors possess delocalized, free electrons that move easily across the material, allowing rapid charge distribution and conduction. Insulators keep their valence electrons tightly bound to atomic nuclei, restricting charge movement to localized polarization without free conduction.

15.5 Discuss how electrostatics plays a role in real-life hazards, such as dust explosions in factories and static shocks from synthetic clothing. How can these hazards be minimized?

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Friction between moving synthetic fibers or flowing flour/dust particles generates large static charges, causing sparks that can ignite airborne dust in factories. These hazards are minimized by grounding conductive equipment, using anti-static wrist straps, maintaining high humidity, and wearing cotton clothing.

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Chapter 16: ELECTRICITY

Short Answer Questions

16.1 How does an ammeter measure electric current?

An ammeter measures electric current by being connected in series with the circuit so that the full stream of charge passes through it. Its internal resistance is near zero to prevent altering the circuit's total current flow.

16.2 What is the main difference between direct current and alternating current?

Direct current (DC) flows continuously in a single fixed direction with constant polarity. Alternating current (AC) periodically reverses its direction of flow and magnitude at a set frequency.

16.3 Define electromotive force (e.m.f.).

Electromotive force (e.m.f.) is the total energy supplied by a non-electrical source (like a battery) per unit charge to drive it around a complete closed circuit. It is expressed as E=QW and measured in volts (V).

16.4 State Ohm's law and define resistivity.

Ohm's law states that current (I) through a conductor is directly proportional to potential difference (V), provided physical conditions remain constant (V=IR). Resistivity (ρ) is the intrinsic resistance of a material of unit length and unit cross-sectional area $(R = \rho\frac{L}{A})$.

16.5 What is the formula for calculating the equivalent resistance of resistors connected in series?

The equivalent resistance (Re) of resistors connected in series is equal to the algebraic sum of their individual resistances: Re=R1+R2+R3+⋯+Rn.

16.6 How does temperature affect the resistance of a conductor?

Increasing the temperature of a metallic conductor causes its lattice atoms to vibrate more vigorously. These intensified vibrations increase collisions with moving free electrons, thereby increasing the conductor's resistance.

Constructed Response Questions

16.1 Why is it important that an ammeter has very low resistance and is connected in series, while a voltmeter has very high resistance and is connected in parallel? What would happen if they were connected incorrectly?
Ammeters are connected in series with low resistance so all current flows through without voltage drops. Voltmeters are connected in parallel with high resistance to draw negligible current. Swapping them causes a series voltmeter to block current flow, while a parallel ammeter creates a severe short circuit.

16.2 If a copper wire is replaced with an aluminum wire of the same dimensions, how would the current and power consumption change in the same circuit? Explain using the concept of resistivity.

Aluminum has higher resistivity than copper (ρAl>ρCu), so the overall wire resistance increases (R=ρAL). Consequently, electric current (I=RV) and power consumption (P=RV2) in the circuit both decrease.

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16.3 In a household lighting circuit, what practical problems might arise if the bulbs were connected in series instead of parallel?

In a series lighting circuit, turning off or burning out one bulb breaks the entire circuit, turning off all other lights. Additionally, total resistance increases with each added bulb, causing all lights to glow dim and receive only a fraction of the supply voltage.

16.4 You are tasked with designing a fuse for a device that operates at 230 V and 5 A. What rating would you choose for the fuse and why? What could go wrong if the rating is too low or too high?

Choose a fuse rating slightly higher than operating current, such as 6 A or 7 A, to allow normal operation while blowing under short-circuit surges. A rating too low blows during normal use; a rating too high fails to melt during faults, leading to fires.

16.5 Explain why A.C is more suitable for power transmission across cities, even though D.C is used in batteries and portable electronic devices.

AC voltage can be easily stepped up to very high voltages using transformers, significantly reducing current and minimizing power loss (I2R) over long transmission lines before stepping down for household use. DC cannot be transformed as easily without complex power conversion.

Comprehensive Questions

16.1 Explain the concept of electric current. How is it related to the movement of charges, and how is it measured in a circuit?

Electric current (I) is the net rate of flow of electric charge through a conductor's cross-section (I=tQ). It is driven by potential difference as free electrons drift toward positive terminals, and it is measured in amperes (A) using a series-connected ammeter.

16.2 Define electromotive force (e.m.f.) and potential difference. How does a battery create a potential difference, and what is the role of e.m.f. in maintaining the flow of current?

Electromotive force (e.m.f.) is energy supplied per unit charge by a source, while potential difference (V) is energy dissipated per unit charge across circuit components. A battery uses internal chemical reactions to create a potential imbalance, continuously pumping charges to maintain steady current.

16.3 State and explain Ohm's law. How does the resistance of a conductor affect the flow of current, and how can Ohm's law be applied in practical electrical circuits? Ohm's law states that current is proportional to voltage (V=IR) assuming constant physical conditions. Higher resistance restricts electron flow, reducing current. In practical design, Ohm's law calculates required resistor values, circuit current loads, and component voltage drops.

16.4 Differentiate between series and parallel combinations of resistors. Provide mathematical expressions for calculating the total resistance in both types of circuits.

In a series circuit, resistors share a single current path, and equivalent resistance is Re=R1+R2+⋯+Rn. In a parallel circuit, components share identical voltage across separate branches, and equivalent resistance is given by Re1=R11 +R21+⋯+Rn1.

16.5 What is meant by resistivity of a material? How does it depend on the material, and what role does temperature play in changing the resistivity of conductors and semiconductors?

Resistivity (ρ) is the intrinsic electrical resistance of a specific material, independent of physical size. In metallic conductors, rising temperatures increase resistivity by boosting atomic vibrations. In semiconductors, higher temperatures release more free charge carriers, decreasing overall resistivity.

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Chapter 17: ELECTROMAGNETISM

Short Answer Questions

17.1 What is the direction of the magnetic field around a straight current carrying wire?

The magnetic field forms concentric circular loops around the wire in a plane perpendicular to it. Its direction is given by the right-hand grip rule, where pointing the thumb along conventional current makes the curled fingers point in the field's direction.

17.2 What happens to the magnetic field if the magnitude of the current in a wire is increased?

If the current increases, the strength of the magnetic field around the wire increases proportionally. This results in denser field lines and stronger magnetic forces exerted on nearby magnetic materials or compass needles.

17.3 How can you identify the north and south poles of an unmarked magnetized steel bar?

Suspend the bar magnet horizontally using a thread so it can rotate freely. The end that points toward the Earth's geographic north is its magnetic north pole, while the end pointing toward geographic south is its magnetic south pole.

17.4 What rule determines the direction of force on a current-carrying conductor placed in a magnetic field? Explain briefly. Fleming's Left-Hand Rule determines the direction of force. Hold the thumb, forefinger, and middle finger mutually perpendicular: the forefinger points in the magnetic field direction, the middle finger along current, and the thumb indicates the force direction.

17.5 What role does the commutator play in a D.C motor?

A split-ring commutator acts as a mechanical reverse switch that flips the direction of current through the rotating coil every half rotation (180∘). This maintains a continuous torque direction, ensuring the coil rotates in one fixed direction.

17.6 What is the source of the Earth's magnetic field according to the theory?

According to dynamo theory, Earth's magnetic field is generated by convection currents of molten iron and nickel moving in its outer core. The rotation of the Earth creates electric currents within this conducting liquid, producing a geomagnetic field.

Constructed Response Questions

17.1 Why does a magnetic field form around a conductor when current flows through it, but not when the current is OFF? What does this reveal about the nature of electricity and magnetism?

Moving electric charges create magnetic fields, whereas stationary charges produce only electric fields. When current is OFF, charges remain static with no net movement, producing no magnetic field. This demonstrates electromagnetism—that electricity and magnetism are interconnected manifestations of charge dynamics.

17.2 In a D.C motor, why does the coil stop turning after 90° if the direction of the current is not reversed? What mechanical feature solves this issue? At 90∘ (vertical position), equal and opposite magnetic forces act along the coil's plane, reducing net torque to zero. Without current reversal, opposing forces brake the coil on passing vertical; a split-ring commutator solves this by reversing current every half turn.

17.3 How does placing a wire at different angles to a magnetic field affect the magnetic force it experiences, and why is this important in designing motors?

The magnetic force varies with angle ($F=ILB\sin\theta$), reaching maximum when perpendicular ($\theta=90^\circ$) and zero when parallel ($\theta=0^\circ$). Motor designers orient coils perpendicular to magnetic fields to maximize torque and power output.

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D. Comprehensive Questions

17.1 How is a magnetic field created around a current-carrying wire, and what factors affect its strength?

The movement of free electrons through a conductor generates a circular magnetic field centered around the wire. Its strength increases with higher electric current (I) and decreases as radial distance (r) from the conductor increases ($B \propto rI$).

17.2 Explain the concept of the right-hand grip rule and how it helps determine the direction of the magnetic field around a current-carrying conductor.

The right-hand grip rule aligns hand geometry with magnetic vectors: curl the fingers of the right hand around the conductor with the thumb pointing in the direction of conventional current. The direction in which the fingers curl shows the magnetic field lines.

17.3 Describe an experiment that demonstrates the magnetic field produced by a current-carrying conductor using a compass or iron filings.

Pass a thick vertical wire through a horizontal cardboard card sprinkled with iron filings. When a strong DC current flows through the wire, tapping the card aligns the filings into concentric circles

around the wire, while plot compasses confirm field direction.

17.4 Discuss the theory behind the Earth's magnetic field and the role of the Earth's molten core in generating it.

The geodynamic theory states that heat from Earth's inner core causes convective motion in the liquid iron-nickel outer core. Earth's rotation drives these conductive fluids in helical patterns, creating continuous electric currents that generate the planet's self-sustaining magnetic field.]

Chapter 18: Electromagnetic Induction and Electromagnetic Waves

Short Answer Questions

18.1 What is the direction of induced current in Lenz's law?

According to Lenz's law, the direction of the induced current is always such that it produces a magnetic field that opposes the change in magnetic flux that caused it.

18.2 Why are slip rings used in an A.C generator?

Slip rings maintain continuous electrical contact between the rotating armature coil and the stationary external circuit, allowing alternating current to flow without tangling or twisting the connecting wires.

18.3 When is induced e.m.f. zero in an A.C generator?

The induced e.m.f. is zero when the plane of the rotating coil is perpendicular to the magnetic field lines ($\theta = 0^\circ$), because the sides of the coil move parallel to the field lines and cut no magnetic flux.

18.4 Why is the sky red at sunset?

At sunset, sunlight travels through a thicker layer of Earth's atmosphere. Shorter blue wavelengths are scattered away by atmospheric particles, leaving mostly longer red and orange wavelengths to reach our eyes.

18.5 What is a transformer and on what principle does it work?

A transformer is a static electrical device that increases or decreases alternating voltage levels. It operates on the principle of mutual induction between two magnetically coupled coils.

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Constructed Response questions

18.1 If a magnet is moved quickly into a coil, a larger e.m.f. is induced. Why does speed affect the magnitude of the induced current?

By Faraday's law of electromagnetic induction ($E=-\Delta t\Delta\Phi$), induced e.m.f. is directly proportional to the rate of change of magnetic flux. Moving the magnet faster decreases Δt, increasing flux linkage rate and inducing a larger current.

18.2 Why is an iron core used in transformers instead of wood or plastic? Explain briefly.

Iron is a ferromagnetic material with high magnetic permeability, which concentrates and efficiently channels magnetic flux from the primary to the secondary coil. Non-magnetic materials like wood or plastic cannot conduct magnetic flux, resulting in severe energy loss.

18.3 How does the concept of photons help explain the working of solar sails in space?

Photons carry momentum despite having no rest mass ($p=\lambda h$). When photons from sunlight strike a reflective solar sail, they transfer momentum upon reflection, producing a continuous propulsive radiation pressure force.

18.4 Why can a transformer work only on alternating current and not on direct current ?

Alternating current continuously changes in magnitude and direction, creating a constantly changing magnetic flux in the core required for mutual induction. Direct current produces a constant magnetic flux ($\Delta t\Delta\Phi=0$), so no e.m.f. is induced in the secondary coil.

D. Comprehensive Questions

18.1 Describe how Lenz's Law supports the law of conservation of energy. Give one real-life example to support your explanation.

Lenz's law ensures energy conservation by requiring mechanical work to overcome the magnetic repulsive/attractive force created by the induced current. That expended mechanical energy transforms into electrical energy; a real-life example is electromagnetic braking systems in modern trains.

18.2 Compare step-up and step-down transformers. Include the difference in number of turns, voltage output, and where is each used.

A step-up transformer has more secondary turns ($Ns>Np$), increasing output voltage ($Vs>Vp$), and is used at power stations for long-distance transmission. A step-down transformer has fewer secondary turns ($Ns<Np$), decreasing output voltage ($Vs<Vp$), and is used in local distribution sub-stations and consumer electronics.

18.3 How does the scattering of sunlight cause the sky to appear blue during the day and red at sunset? Explain.

Rayleigh scattering is inversely proportional to wavelength ($Scattering\propto\lambda 41$). During the day, short blue wavelengths scatter in all directions across the atmosphere. At sunset, sunlight passes through a thicker atmospheric path, scattering away blue light and transmitting longer red wavelengths.

18.4 What is an oscilloscope, and how does it help in analyzing electrical signals? Describe its main components.
An oscilloscope is an electronic instrument that displays voltage signals visually as two-dimensional graphs against time. Its main components include an electron gun, vertical/horizontal deflection plates, a time-base generator, and a fluorescent/LCD screen.

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18.5 What is the shape of the path followed by an electron when it moves at right angles to a uniform magnetic field? Explain why.

An electron follows a circular path because the magnetic force (F=qvB) acts perpendicular to both its velocity vector and the magnetic field lines. This constant perpendicular force acts strictly as a centripetal force (Fc=rmv2), changing only velocity direction without altering speed.

Chapter 19: ELECTRONICS

Short Answer Questions

19.1 What is the function of a semiconductor diode?

A semiconductor diode acts as a one-way electrical valve that allows current to flow easily in only one direction (forward bias) while blocking current in the opposite direction (reverse bias).

19.2 What happens when a diode is forward biased?

When forward biased, the external voltage overcomes the internal barrier potential, narrowing the depletion region and allowing electric current to flow freely through the diode.

19.3 What is the function of an LED?

A Light Emitting Diode (LED) is a specialized p-n junction diode that converts electrical energy directly into visible light or infrared radiation when forward biased.

19.4 Why does an LED emit light when current passes through it?

When forward biased, electrons cross the junction and recombine with holes. As electrons drop into lower energy states, they release their excess energy in the form of discrete photons of light.

19.5 What does an analog-to-digital converter (ADC) do?

An ADC converts continuously variable analog signals (like real-world sound waves or temperature measurements) into discrete binary code (0s and 1s) suitable for digital processing.

19.6 What is the difference between analog and digital signals?

Analog signals are continuous voltage or current waves that vary smoothly over time, whereas digital signals consist of discrete, two-state binary levels (HIGH/LOW or 1/0).

19.7 What is Boolean logic in digital electronics?

Boolean logic is a mathematical system that operates on binary variables having two possible values: TRUE (1) or FALSE (0). It forms the core algebraic foundation for designing digital circuits and decision-making logic.

19.8 What does a NOT gate do in a digital circuit?

A NOT gate (inverter) inverts its input signal: it outputs a LOW signal (0) when the input is HIGH (1), and a HIGH signal (1) when the input is LOW (0).

19.9 What is the role of an AND gate in digital circuits? An AND gate performs logical multiplication, producing a HIGH (1) output only when **all** of its input signals are simultaneously set to HIGH (1).

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Constructed Response Questions

19.1 Why would a diode be damaged if it is connected in reverse bias with a very high voltage? What does this tell us about the diode's physical limits?

A very high reverse voltage causes catastrophic avalanche breakdown, driving an excessive reverse current that generates intense heat and permanently burns the crystal structure. This defines the diode's maximum allowable Peak Inverse Voltage (PIV).

19.2 What makes an LED glow brighter or dimmer depending on the voltage applied? How is this property used in adjustable display brightness?

Increasing forward voltage increases the current flow, leading to a higher rate of electron-hole recombinations and greater photon production (brighter light). Displays utilize Pulse Width Modulation (PWM) or variable voltage drivers to control brightness precisely.

19.3 Why are digital systems more reliable than analog systems when transmitting signals over long distances? Digital signals represent distinct discrete states (0 and 1) rather than continuous amplitudes. Noise added during long-distance transmission can be filtered out easily without altering the original binary values, whereas analog signals permanently distort when noise is added.

19.4 Why is the NOT gate also called an inverter, and how can such a simple function have a major role in digital decision-making?

It is called an inverter because it reverses the logic state of its input signal. Inverting signals is essential for complement operations, forming basic flip-flop memory units, creating clock oscillators, and building universal logic architectures like NAND and NOR gates.

19.5 Why would a security system use NAND gates instead of OR or AND gates for certain logical conditions? NAND gates are universal logic gates capable of replicating any other logic operation (AND, OR, NOT) using a single gate type. This simplifies overall circuit manufacturing, reduces component costs, and provides flexible conditional logic required for alarm triggers.

D. Comprehensive Questions

19.1 Explain how the depletion region of a diode changes in forward and reverse bias. What effect does this have on current flow?

In forward bias, external potential reduces the barrier potential, narrowing the depletion region to allow high current flow. In reverse bias, external potential pulls charge carriers away from the junction, widening the depletion region and blocking current except for a tiny leakage current.

19.2 Describe how an LED produces light. Also explain how the type of semiconductor material affects the colour of the light.

An LED produces light through electroluminescence during forward-bias electron-hole recombination. The energy bandgap (Eg) of the compound semiconductor material determines the photon wavelength ($\lambda = Eghc$), dictating the color emitted (e.g., GaAs produces infrared, while GaN emits blue light).

19.3 What is Boolean logic? Discuss its importance in solving complex digital problems with examples. Boolean logic is binary mathematical logic using operations like AND, OR, and NOT. It simplifies complex real-world control systems—such as automated safety shut-offs or traffic light timing circuits—into systematic algebraic expressions that can be directly implemented using physical digital hardware.

19.4 What are logic gates? Describe the working of NAND and OR gates with the help of truth tables and circuit symbols.

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Logic gates are physical electronic circuits that implement Boolean functions. An OR gate outputs 1 if at least one input is 1, while a NAND gate outputs 0 only when all inputs are 1.

- **OR Gate:** Y=A+B

(Truth Table: 0+0=0, 0+1=1, 1+0=1, 1+1=1)

- **NAND Gate:** Y=A·B

(Truth Table: 0·0=1, 0·1=1, 1·0=1, 1·1=0)

19.5 How does a NOR gate work, and how can it be used to build other basic logic gates?

A NOR gate produces a HIGH (1) output only when all inputs are LOW (0). As a universal gate, tying its inputs together forms a **NOT** gate; connecting its output to a NOT gate creates an **OR** gate; and placing NOT gates on its inputs produces an **AND** gate (A·B=A+B).

19.6 How can a burglar alarm be designed using a NAND gate and an LDR? Explain.

An Light Dependent Resistor (LDR) forms a voltage divider connected to one input of a NAND gate. In daylight, low LDR resistance holds the input HIGH (1). In darkness, high LDR resistance drops the input to LOW (0), switching the NAND gate output to HIGH (1) to trigger an alarm buzzer.

Chapter 20: ATOMIC AND NUCLEAR PHYSICS

Short Answer Questions

20.1 Define the atomic nucleus. What are its two main characteristics?

The atomic nucleus is the extremely dense, positively charged central core of an atom containing protons and neutrons. Its two main characteristics are containing nearly all of the atom's total mass and occupying a tiny fraction of its total volume.

20.2 What is the structure of an atom according to Rutherford's model?

Rutherford's model states that an atom consists of a tiny, dense, positively charged central nucleus surrounded by negatively charged electrons orbiting in empty space, much like planets orbiting the Sun.

20.3 How does alpha radiation differ from beta radiation?

Alpha radiation consists of positively charged helium nuclei (24He) with high ionizing power and low penetration. Beta radiation consists of high-speed electrons or positrons (−10e) with lower ionizing power but much higher penetrating ability.

20.4 What is the primary energy source of the Sun and other stars?

The primary energy source of the Sun and stars is nuclear fusion, where hydrogen nuclei undergo proton-proton chain reactions under extreme temperature and pressure to form helium, releasing vast amounts of energy.

20.5 Name the equation proposed by Einstein that relates energy and mass.

The equation is Einstein's mass-energy equivalence formula, written as E=mc2, where E is energy, m is mass defect, and c is the speed of light in a vacuum (3×108 m/s).

20.6 What is the principle behind carbon dating and its applications?

Carbon dating measures the decay of radioactive Carbon-14 (14C) relative to stable Carbon-12 in organic remains. Since 14C decays at a known half-life (5730 years), measuring this ratio estimates the age of ancient fossils, wood, and artifacts.

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20.7 Define nuclear fusion with an example.

Nuclear fusion is the process in which two light atomic nuclei combine to form a heavier nucleus, releasing massive energy. An example is the fusion of deuterium (12H) and tritium (13H) to form helium (24He) and a neutron.

20.8 Americium-241 (95241Am) undergoes alpha decay and produces an alpha particle. Write down the chemical equation for it and name the nucleus formed.

The nuclear reaction equation is:

95241Am→93237Np+24He

The nucleus formed is Neptunium-237 (93237Np).

Constructed Response Questions

20.1 If an atom is mostly empty space, why do not we fall through solid objects or pass through walls?

We do not pass through solid objects because the negative electron clouds of the atoms in our body strongly repel the electron clouds of the atoms in the wall via electrostatic repulsion, while the Pauli exclusion principle prevents overlapping electron orbitals.

20.2 Imagine a new radioactive element is discovered. How could scientists estimate its half-life without waiting thousands of years?

Scientists can measure the sample's current decay rate (activity, A) and the total number of undecayed nuclei (N) present. Using the radioactive decay law (A=λN), they calculate the decay constant (λ) and find the half-life via t1/2 =λ0.693.

20.3 If gamma rays do not change the number of protons or neutrons in a nucleus, why are they still considered dangerous?

Gamma rays are highly energetic electromagnetic photons with extreme penetrating power. They easily pass through human tissue, causing deep cellular ionization, damaging DNA strands, and triggering cancerous mutations or severe radiation sickness.

20.4 If carbon-14 stopped forming in the atmosphere today, how would that affect the use of carbon dating in the future?

Existing 14C would continuously decay without replenishment, depleting the atmospheric 14C to 12C equilibrium ratio. Eventually, organisms dying after this collapse would lack measurable 14C, rendering future organic dating impossible.

20.5 What is the difference between nuclear fission and nuclear fusion in terms of process and energy release?
Fission splits a heavy nucleus into lighter fragments, whereas fusion combines light nuclei into a heavier one. Per unit mass, nuclear fusion releases significantly more energy than fission and produces no long-lived radioactive nuclear waste.

Comprehensive Questions

20.1 How does the structure of an atom determine its chemical properties? Explain with reference to the arrangement of protons, neutrons, and electrons.

The number of protons determines the atomic number, which equals the number of electrons in a neutral atom. The arrangement of valence electrons in the outermost energy shell governs chemical reactivity, bonding behavior, and valence, while neutrons affect only mass and nuclear stability.

20.2 Explain Einstein's equation; E=mc2, and its significance. How does this equation relate to nuclear reactions?

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Einstein's equation demonstrates that mass and energy are interchangeable. In nuclear reactions, the total mass of the products is slightly less than the reactants; this missing mass ("mass defect", Δm) converts directly into kinetic and thermal energy via E=Δmc2.

20.3 Describe the process of radioactive decay and how it leads to the emission of alpha, beta, and gamma radiation?

Unstable atomic nuclei seek stability by spontaneously emitting radiation. Emitting an alpha particle reduces mass and charge; emitting a beta particle transforms a neutron to a proton (or vice versa); and emitting gamma rays releases excess excitation energy without altering nucleon counts.

20.4 Why do different isotopes of the same element have similar chemical properties but different physical properties? Explain.

Isotopes possess the exact same atomic number and identical valence electron configurations, which dictates chemical reactivity. They differ in neutron count and atomic mass, altering mass-dependent physical properties such as density, melting point, diffusion rate, and nuclear stability.

20.5 Explain how carbon dating uses carbon-14 to estimate the age of artifacts. Discuss its reliability, considering the influence of carbon-14's half-life?

Living organisms absorb 14C keeping a constant ratio with 12C; upon death, 14C decay begins at a half-life of 5730 years. Measuring residual 14C yields reliable dates up to ~50,000 years, beyond which remaining 14C levels become too small to measure accurately.

Chapter 21: SPACE AND ENVIROMENT

Short Answer Questions

21.1 What are the two main elements that make up the Sun?

The two main elements that make up the Sun are hydrogen (about 73%) and helium (about 25%).

21.2 What factors are used to compare planets in terms of their characteristics?

Planets are compared based on mass, size/radius, average density, atmospheric composition, orbital period, surface temperature, and the presence of natural satellites or rings.

21.3 Explain how global warming increases the intensity of hurricanes.

Global warming raises ocean surface temperatures, providing increased thermal energy and moisture that fuel tropical storms, leading to higher wind speeds and heavier rainfall.

21.4 What is background radiation, and what are its natural sources?

Background radiation is the low-level ionizing radiation constantly present in the environment. Natural sources include cosmic rays from outer space, radon gas in air, and radioactive isotopes in soil and rocks.

21.5 Name three safety measures used to handle radioactive materials safely.

Three key safety measures are using lead or concrete shielding, maintaining maximum possible distance from the source, and minimizing the duration of exposure.

21.6 Why do cyclones weaken when they move over land?

Cyclones weaken over land because they are cut off

from their primary energy source—warm ocean water evaporation—and encounter increased surface friction from terrestrial landforms.

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21.7 How does the Coriolis Effect influence the movement of cyclones?

The Coriolis Effect deflects moving air masses to the right in the Northern Hemisphere and to the left in the Southern Hemisphere, causing cyclones to rotate counterclockwise and clockwise, respectively.

21.8 What is the primary cause of rising sea levels due to global warming?

The primary causes are the thermal expansion of warming ocean waters and the melting of glaciers and polar ice sheets.

C. Constructed Response Questions

21.1 Why do gas giants like Jupiter, despite their larger size, have lower densities than rocky planets such as Earth and Mars? What does this tell us about their internal structure?

Gas giants are composed predominantly of light elements like hydrogen and helium rather than dense metals and silicates. This indicates they lack solid rocky surfaces and consist of deep, massive fluid atmospheres surrounding relatively small cores.

21.2 If two planets receive the same amount of sunlight but have different atmospheric compositions, why might their surface temperatures still differ significantly?

Atmospheric composition determines the greenhouse effect: a planet with a dense atmosphere rich in greenhouse gases (like CO2) traps outward thermal radiation, producing much higher surface temperatures than a planet with a thin or non-greenhouse atmosphere.

21.3 How does the coriolis effect play a role in creating the spiraling motion of cyclones, and what might happen to cyclone formation if the Earth stopped rotating?

The Coriolis Effect deflects inward-rushing surface winds into a circular swirl around a low-pressure center. If Earth stopped rotating, the Coriolis force would drop to zero, causing air to flow straight into low-pressure zones without spiraling, preventing cyclone formation.

21.4 Compare the ways radiation, conduction, and convection each contribute to geothermal activity. Why is convection considered the primary driver of tectonic plate motion?

Conduction transfers thermal energy through solid mantle rocks, radiation dissipates heat into space at the surface, and convection moves heated mantle material in circular currents. Convection drives plate motion because large-scale mantle plumes physically carry overlying lithospheric plates.

21.5 Explain why background radiation is always present in our environment and how cosmic and terrestrial sources balance each other despite fluctuations in human activity.

Background radiation persists continuously because unstable isotopes exist naturally within Earth's crust and cosmic rays perpetually strike the atmosphere. These natural processes release steady levels of radiation independent of human technological activities.

D. Comprehensive Questions

21.1 Describe the process of nuclear fusion in the Sun and explain how it generates energy.

Nuclear fusion in the Sun's core fuses hydrogen nuclei into helium through the proton-proton chain reaction at extreme temperatures and pressures. A small mass defect (Δm) in each reaction converts directly into immense energy according to $E=\Delta mc2$.

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21.2 How does a planet's orbital distance affect its surface temperature and the amount of solar energy it receives?

Solar irradiance decreases with distance following the inverse-square law ($I \propto r^{21}$). Planets orbiting further away receive significantly less solar radiation per unit area, resulting in lower baseline surface temperatures.

21.3 Explain the role of convection in the formation and strengthening of cyclones.

Solar heating causes warm, moist air over tropical oceans to rise rapidly through atmospheric convection. As this air rises, water vapor condenses to release latent heat, which further warms the surrounding air, drives stronger updrafts, and intensifies the low-pressure system.

21.4 What are the major sources of background radiation, and how does human activities contribute to it?
Major natural sources include cosmic rays, terrestrial rocks, and atmospheric radon. Human activities contribute additional background radiation through medical imaging (X-rays, CT scans), historical nuclear testing fallout, industrial isotopes, and nuclear power generation.

21.5 Explain how radiation exposure can be harmful and describe three key safety measures used to minimize its risks.

High-energy ionizing radiation strips electrons from atoms, damaging biological molecules and DNA, which can lead to cell death or cancerous mutations. Exposure risks are minimized using:

- **Shielding:** Absorbing radiation with dense materials like lead or thick concrete.
- **Distance:** Maximizing distance from sources to leverage inverse-square reduction.
- **Time:** Minimizing exposure duration to reduce cumulative dosage.

Overall Summary by Category

Question Category	*Total Count*
Short Answer Questions	49
Constructed Response Questions (CRQs)	32
Comprehensive Questions	35
Total Short & Conceptual Questions (B + C)	81
Grand Total Questions Provided	116

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