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Physics, 2018 EC, entrance exam, round 3, booklet 655

Grade 12 · Physics · 2018 E.C.

MARKING KEY — CONFIDENTIAL

Time allowed: 120 minutes | **Questions:** 55 | **Total marks:** 55

1. During a charging process by induction, a positively charged rod is brought closed to a neutral metal sphere mounted on an insulated stand without touching it. Then, the metal sphere: (1)

A. becomes positively charged, whenever it is grounded.

B. loses some electrons, whenever it is grounded.

C. ✓ **gains some electrons, whenever it is grounded.**

D. gains some protons whenever it is grounded.

> **Answer:** C
> During induction, when a positively charged rod is brought near a neutral metal sphere and the sphere is grounded, free electrons from the ground flow to the sphere to neutralize the positive charge on the side opposite the rod, making the sphere gain electrons.

2. A positively charged rod is brought near to a neutral electroscope A and a negatively charged rod is brought near to a neutral electroscope B. What will happen to the gold foils of the electroscopes? The gold foils of: (1)

A. both electroscopes attract each other.

B. ✓ **both electroscopes repel each other.**

C. electroscope A repels and that of B attracts each other.

D. electroscope A attract and that of B repels each other.

> **Answer:** B
> When any charged rod (whether positive or negative) is brought near a neutral electroscope, charges are induced on the leaves. Since both leaves receive like charges, they repel each other.

3. A particle moving with a speed of v0 to the right starts accelerating uniformly with acceleration a. The total distance covered by the particle during the time interval t is s. Assuming the right direction is positive, which one of the following equations enables us to calculate the time t in terms of v0, a and s? (1)

A. ✓ **t= [-v0+ √(v02+ 2as)] /a**

B. t= [-v0+ √(v02+ 2as)] / 2a

C. t= [v0+ √(v02+ 2as)] /a

D. t= [v0- √(v02+ 2as)] / 2a

> **Answer:** A
> Using the kinematic equation: s = v0t + (1/2)at2. Rearranging gives the quadratic equation: (a/2)t2 + v0t - s = 0. Solving for t using the quadratic formula yields the positive root: t = [-v0 + √(v02 + 2as)] / a.

4. The figure shown below represents the position-time graph of uniformly accelerated ball in a straight line. The instantaneous velocity of the ball at point x is equal to: (1)

[Figure: A position-time graph with a vertical axis labeled Position (m) and a horizontal axis labeled Time (s). The vertical axis has three marked points from bottom to top: S1, S2, and S3. The horizontal axis has three marked points from left to right: t1, t2, and t3, with dashed vertical lines extending upward from each to a curve. A curved line representing motion starts at position S1 at time t1 and rises to position S3 at time t3. On the curve, a marked point labeled x corresponds to position S2 and time t2, with dashed lines going from point x to S2 on the vertical axis and t2 on the horizontal axis.]

A. the average velocity during the time interval betweent1andt3.

B. the ratio of the position at x (s2) to the timet2.

C. the total distance travelled to the total time,t3-t1.

D. ✓ **the slope of the tangent line at point x.**

> **Answer:** D
> By definition, the instantaneous velocity of a moving object at any point on a position-time graph is equal to the slope of the tangent line drawn at that point.

5. A weight of 1000 N suspended from an aluminum wire of length 2.5 m causes a 4.0 × 10-3 tensile strain on the wire. What is the change in length of the aluminum wire? (1)

A. 10 cm

B. 0.01 cm

C. 0.1 cm

D. ✓ **1 cm**

> **Answer:** D
> Tensile strain is defined as ΔL / L. Therefore, ΔL = strain × L = (4.0 × 10-3) × 2.5 m = 0.01 m = 1 cm.

6. For a coil placed in a variable magnetic field, Lenz's law states that the direction of the induced current in the coil is in such a way as to: (1)

A. ✓ **oppose the flux change through the coil.**

B. make the flux through the coil zero.

C. increase the flux through the coil.

D. decrease the flux through the coil.

> **Answer:** A
> Lenz's Law states that the direction of the induced current in a conductor is such that it creates a magnetic field opposing the change in the magnetic flux that induced it.

7. Considering the concentration of dopants in different section of a transistors, which one of the following describes a correct order from lowest to highest? (1)

A. Collector, Base, Emitter

B. ✓ **Base, Collector, Emitter**

C. Emitter, Base, Collector

D. Base, Emitter, Collector

> **Answer:** B
> In a bipolar junction transistor, the doping concentration of the base is the lowest, followed by the collector, and the emitter is heavily doped to maximize charge carrier injection. Thus, the order is Base, Collector, Emitter.

8. Which of the following circuit diagrams correctly represents a transistor configurations that is used to get both current and voltage gain? (1)

[Figure: The image shows four circuit diagrams labeled A, B, C, and D for question 9. Diagram A shows an NPN transistor with base B as input, collector C at the top, and emitter E at the bottom connected to the common line, with an upward arrow for output. Diagram B shows a transistor with collector C on the left, emitter E on the right, and base B at the bottom connected to the common line. Diagram C shows a transistor with base B on the left as input, emitter E at the top, and collector C at the bottom connected to the common line. Diagram D shows a transistor with emitter E on the left, collector C on the right, and base B at the bottom connected to the common line.]

A. ✓ **Diagram A**
B. Diagram B
C. Diagram C
D. Diagram D

> **Answer:** A
> The Common-Emitter (CE) transistor configuration is the only configuration that provides both substantial voltage gain and current gain.

9. If the magnitude of magnetic field produced at a distance of 2 cm from a long straight current carrying wire is 1.2 T, then what is the magnitude of magnetic field at a distance of 3 cm from the wire? (1)

A. 0.6 T
B. 1.2 T
C. ✓ **0.8 T**
D. 1.8 T

> **Answer:** C
> The magnetic field produced by a long straight current-carrying wire is inversely proportional to the distance: B1r1 = B2r2 &implies; (1.2 T)(2 cm) = B2(3 cm) &implies; B2 = 0.8 T.

10. Suppose a 50 Hz outlet voltage of 10,000 V needs to be reduced to 220 V using a stepdown transformer. How many turns does the primary coil on the transformer have if the secondary coil has 110 turns? (1)

A. 550
B. ✓ **5000**
C. 110
D. 1000

> **Answer:** B
> For an ideal transformer: Vp / Vs = Np / Ns &implies; 10,000 / 220 = Np / 110 &implies; Np = (10,000 × 110) / 220 = 5000 turns.

11. The acceleration of an object is defined as the time rate of change in: (1)

A. displacement of the object.
B. distance travelled by the object.
C. position of the object.
D. ✓ **velocity of the object.**

> **Answer:** D
> Acceleration is defined as the rate of change of velocity with respect to time.

12. The efficiency of a simple machine is defined as the ratio between: (1)

A. ✓ **mechanical advantage and velocity ratio.**
B. work input and velocity ratio.
C. work output and mechanical advantage.
D. work output and velocity ratio.

> **Answer:** A
> The efficiency of a simple machine can be defined as the ratio of mechanical advantage (MA) to velocity ratio (VR).

13. Static friction force is different from kinetic friction force in that, it: (1)

A. is a friction force between two objects that are moving relative to each other.

B. has higher value in smooth surfaces than in rough surfaces.

C. ✓ **is a friction force between two objects that are at rest relative to each other.**

D. has a maximum value which is often lower than the kinetic friction force.

> **Answer:** C
> Static friction is the friction force that opposes the initial relative motion of two objects that are at rest relative to each other.

14. Which one of the following statements is correct about simple machines? (1)

A. A machine which is designed so that its mechanical advantage is less than 1 is called a force multiplier.

B. ✓ **When a machine is designed so that its velocity ratio is less than 1 is called a speed multiplier.**

C. A machine can be designed to be a force multiplier, a speed multiplier, and a direction changer at the same time.

D. When a machine is designed so that its velocity ratio is greater than 1, it is called a speed multiplier.

> **Answer:** B
> A machine with a velocity ratio (VR) less than 1 is a speed multiplier because the distance moved by the load is greater than the distance moved by the effort.

15. A forklift truck applied a force of F = 30 N, East on an object and dragged it through a distance of 200 m along a horizontal frictionless surface in a time of 5 minutes. The average power output of the truck is: (1)

A. ✓ **20 W**

B. 200 W

C. 1800 W

D. 1200 W

> **Answer:** A
> Work done = Force × distance = 30 N × 200 m = 6000 J. Time = 5 minutes = 300 s. Average power = Work / Time = 6000 J / 300 s = 20 W.

16. The velocity-time graph of a moving object along a straight line is shown in the figure below. What is the total displacement of the object during the total period of motion? (1)

[Figure: A velocity-time graph plotted on a grid with a vertical axis labeled Velocity (m/s) ranging from -2 to 2 with major grid lines at integers, and a horizontal axis labeled Time (s) ranging from 0 to 12 with major grid lines every 2 units. The graph starts at the origin (0, 0), rises linearly to (2, 2), stays constant at a velocity of 2 m/s until t = 6 seconds, decreases linearly to 0 m/s at t = 8 seconds, continues decreasing linearly below the time axis to a minimum velocity of -2 m/s at t = 9 seconds, then increases linearly back to 0 m/s at t = 10 seconds, and remains flat at 0 m/s until t = 12 seconds.]

A. 14 m

B. 8 m

C. ✓ **10 m**

D. 12 m

> **Answer:** C
> Total displacement is the area under the v-t graph. From t = 0 to t = 8: Area is a trapezoid with bases 4 and 8, height 2: Area1 = [(4 + 8) / 2] × 2 = 12 m. From t = 8 to t = 12: Area is a triangle below the axis with base 4, height -1: Area2 = (1/2) × 4 × (-1) = -2 m. Total displacement = 12 - 2 = 10 m.

17. Which one of the following statements correctly defines the characteristic feature of a mechanical waves? (1)

A. The number of complete waves passing a given point per second is called time period.

B. The distance between two adjacent peaks of the wave is called amplitude.

C. The distance that the wave travels in one second is called frequency.

D. ✓ **The minimum distance between two identical points on adjacent waves is called wavelength.**

> **Answer:** D
> Wavelength is defined as the minimum distance between any two points that are in the same phase of oscillation on adjacent waves.

18. The speed of sound is greatest in which one of the following materials? (1)

A. Water

B. ✓ **Copper**

C. Oil

D. Air

> **Answer:** B
> Sound waves travel faster in solids than in liquids or gases due to the high elastic modulus and density of solids. Copper is the only solid among the options.

19. Which one of the following statements is correct about graphical and algebraic representation of a vector? Vector is represented: (1)

A. ✓ **graphically by an arrow in which the length of the arrow represents the magnitude of the vector to the appropriate chosen scale.**

B. graphically by an arrow in which the length of the arrow is equal to the magnitude of the vector.

C. algebraically by a segment line in which the length of the segment line represents the magnitude of the vector.

D. graphically by a bold letter A or with an arrow over the letter like &vec;A.

> **Answer:** A
> Graphically, a vector is represented by an arrow where the direction represents the vector's direction, and the length is scaled proportionally to represent its magnitude.

20. A simple first-class lever machine is used to lift a load of 500 N by applying an effort of 300 N, as shown in the diagram below. What is the velocity ratio of the machine? (1)

[Figure: The diagram shows a first-class lever machine consisting of a horizontal bar resting on a triangular fulcrum in the middle. On the left side of the fulcrum, a cylindrical load labeled Load is placed, with a dashed vertical line indicating the distance from the fulcrum to the load as 2 m. On the right side of the fulcrum, a downward vertical arrow labeled Effort points to the end of the lever, with a dashed vertical line indicating the distance from the fulcrum to the effort as 5 m. A horizontal base line runs underneath the entire lever setup.]

A. 0.40

B. 0.60

C. ✓ **2.50**

D. 1.67

> **Answer:** C
> The velocity ratio of a first-class lever is the ratio of the effort arm to the load arm: VR = Effort Arm / Load Arm = 5 m / 2 m = 2.50.

21. A car moves at speed of 80.0 km/hr for 1.0 hour to East then back to West in which it travels at speed of 60.0 km/hr for 2.0 hrs. What is the average velocity of the car during its motion? (1)

A. 66.7 km/hr, West
B. ✓ **13.3 km/hr, West**
C. 66.7 km/hr, East
D. 13.3 km/hr, East

> **Answer:** B
> Eastward displacement = 80.0 km/hr × 1.0 hr = 80.0 km. Westward displacement = 60.0 km/hr × 2.0 hr = 120.0 km. Net displacement = 80.0 - 120.0 = -40.0 km (40.0 km West). Total time = 3.0 hrs. Average velocity = -40.0 / 3.0 = -13.3 km/hr, which is 13.3 km/hr, West.

22. Pascal's principle states that a pressure added at the top of a liquid at rest in a cylindrical shape container: (1)

A. increases the pressure at any point in the liquid by a greater amount than that added at the top.
B. ✓ **increases the pressure at any point in the liquid by the same amount as that added at the top.**
C. decreases the pressure at any point in the liquid by the same amount as that added at the top.
D. increases the pressure at any point in the liquid by a smaller amount than that added at the top.

> **Answer:** B
> Pascal's principle states that a pressure change applied to an enclosed fluid is transmitted undiminished to every portion of the fluid and the walls of its container.

23. A high-pressure system can be applied to: (1)

A. reduce the gas in the bicycle and car tires.
B. biological sample to increase micro-organism activity.
C. ✓ **transport a fluid through a pipe.**
D. generate cold water from steam or super-heated water.

> **Answer:** C
> A high-pressure system can be applied to transport fluids over long distances through piping networks.

24. Which one of the following statements is correct about the characteristics of steady and turbulent fluid flow? (1)

A. ✓ **In steady flow, the adjacent layers of fluid do not cross each other unlike in the turbulent flow.**
B. In each flow, the lines along which fluid particles move do not cross each other.
C. In each flow, fluid particles pass a given point in space with the same velocity.
D. In turbulent flow, the velocity of a fluid particles is the same at same point of a flow line in space unlike in the steady flow.

> **Answer:** A
> In steady flow, fluid layers glide smoothly past one another without mixing, meaning the streamlines do not cross, unlike in turbulent flow where chaotic mixing occurs.

25. Our planet Earth has an orbital period of 365 days and its mean distance from the Sun is Re = 1.495 × 108 km. If there is another unknown planet whose mean distance from the Sun is R = 4Re, how much is an orbital period of the unknown planet in terms of the days on the Earth? (1)

A. 1460 days
B. 730 daysn
C. 23360 days
D. ✓ **2920 days**

> **Answer:** D
> Kepler's Third Law states T2 is proportional to R3. Thus, (T / Te)2 = (R / Re)3 = 43 = 64. Taking the square root gives T / Te = 8, so T = 8 × 365 = 2920 days.

26. A unit vector is defined as: (1)

A. a small vector in the direction of a given vector.

B. a vector of magnitude zero, with arbitrary direction.G

C. a vector of magnitude one, with specified unit.

D. ✓ **a vector of magnitude one, with no unit. tx**

> **Answer:** D
> A unit vector is defined as a vector of magnitude exactly equal to one, used solely to point in a specific direction, and has no physical units.

27. Which of the following statements does NOT explain the importance of physics to society? Physics helps society by its direct contribution in: (1)

A. the development of medical equipment.

B. the development of cleaner energy sources.

C. ✓ **maintaining equality and justice in the society.**

D. developing strategies to combat climate change.

> **Answer:** C
> Maintaining equality and justice is a socio-political goal, whereas the other options describe direct applications of physical science.

28. To form an image of a distant object, the refracting telescope uses: (1)

A. a convex mirror to collect light and forms an image which is magnified by the convex lens of the eyepiece.

B. ✓ **an objective convex lens to collect light and form an image which is magnified by the convex lens of the eyepiece.**

C. a convex mirror to collect light and forms an image which is magnified by the concave lens of the eyepiece.

D. an objective concave lens to collect light and forms an image which is magnified by the concave lens of the eyepiece.

> **Answer:** B
> A refracting telescope uses a large objective convex lens to gather light and form a real image, which is then magnified by a smaller eyepiece convex lens.

29. Two plane mirrors inclined at an angle of 72° to each other. How many images are formed when an object is placed between them? (1)

A. 5

B. 3

C. 6

D. ✓ **4**

> **Answer:** D
> The number of images formed by two inclined plane mirrors is n = (360/θ) - 1 = (360/72) - 1 = 5 - 1 =

30. Given two vectors P = -5i + 3j and Q = 2i + j, what is the dot product of the vectors? (1)

A. 7

B. -13

C. 13

D. ✓ **-7**

> **Answer:** D
> The dot product of two vectors is: P . Q = (-5)(2) + (3)(1) = -10 + 3 = -7.

31. During collision between two objects, the impulse imparted on each object is equal to the: (1)

A. net force acting on the object divided by the time for collision.

B. ✓ **change in momentum of the object.**

C. product of change in momentum and time for collision.

D. change of momentum of the object divided by the time for collision.

> **Answer:** B
> The impulse-momentum theorem states that the impulse imparted on an object is equal to its change in momentum.

32. The displacement versus time graph of an object undergoing linear motion is shown in the figure below. For the motion during the time interval between: (1)

[Figure: The figure is a displacement versus time graph for an object undergoing linear motion. The vertical axis is labeled Displacement (m) with an arrow pointing upwards. The horizontal axis is labeled Time (s) with an arrow pointing to the right, and the origin is marked as 0. The graph curve starts at the origin 0 and curves upwards with an increasing slope until time t1. From t1 to t2, the curve is a horizontal straight line parallel to the time axis. From t2 to t3, the curve is a straight line sloping upwards with a constant positive slope. Dashed vertical lines drop from the curve to the time axis at points t1, t2, and t3.]

A. t2and t3, the object is moving with a non-zero constant acceleration.

B. t2and t3, the velocity of the object is increasing and it is accelerating.

C. ✓ **0 and t1, the velocity of the object is increasing and it is accelerating.**

D. t1and t2, the object is moving with a non-zero constant velocity.

> **Answer:** C
> During the interval 0 to t1, the slope of the displacement-time curve is non-zero, representing a moving object.

33. In an automobile that contains engine and fuel, chemical energy of the fuel is partially converted to kinetic energy of the automobile and partially to thermal energy. In this process, the: (1)

A. energy of the automobile is not conserved because it does not exist persistently in chemical form.

B. kinetic energy of the automobile is considered as a created energy because it appears in a new form.

C. amount of energy converted to thermal energy is considered as destroyed because it decreases the efficiency of the automobile.

D. ✓ **energy of the automobile is conserved because it is not destroyed but converted to kinetic and thermal energies.**

> **Answer:** D
> Energy can neither be created nor destroyed, only transformed from one form to another. The total energy remains constant as chemical energy is converted to kinetic and thermal energy.

34. A uniform disk of radius 10.0 cm is rotating at an angular velocity of 20.0 rad/s about an axis through its center. What is the centripetal acceleration of a point at a distance of 6.0 cm from the axis? (1)

A. ✓ **24.0 m/s2**

B. 40.0 m/s2

C. 2.0 m/s2

D. 1.2 m/s2

> **Answer:** A
> Centripetal acceleration is given by: ac = ω2 r = (20 rad/s)2 × (0.06 m) = 400 × 0.06 = 24.0 m/s2.

35. A block of mass 20.0 kg is placed on a horizontal surface. If the coefficient of kinetic friction between the block and the surface is 0.25, what force must be applied on the block to accelerate it uniformly with 3.0 m/s2? (1)

A. 50 N
B. 40.0 m/s2
C. ✓ **110 N**
D. 10 N

> **Answer:** C
> The kinetic friction force is: fk = μk m g = (0.25)(20 kg)(10 m/s2) = 50 N. The net force is: Fnet = m a = (20 kg)(3 m/s2) = 60 N. Total applied force is: F = Fnet + fk = 60 N + 50 N = 110 N.

36. A 0.3 kg ball moving with a velocity of 0.9 m/s along the positive x-axis collides with a 0.2 kg ball moving with a velocity of 1.2 m/s along the negative x-axis. What is the velocity of the center of mass of the two balls before collision? (1)

A. 1.02 m/s along the negative x-axis
B. 0.06 m/s along the negative x-axis
C. 1.02 m/s along the positive x-axis
D. ✓ **0.06 m/s along the positive x-axis**

> **Answer:** D
> The velocity of the center of mass is: vcm = (m1v1 + m2v2) / (m1 + m2). Let the positive direction be to the right: vcm = [(0.3)(0.9) + (0.2)(-1.2)] / (0.3 + 0.2) = 0.03 / 0.5 = 0.06 m/s along the positive x-axis.

37. What amount of heat energy is required to raise the temperature of 0.15 kg of silver from 20°C to 100°C? (Specific heat capacity of silver is 233.0 J/kg.°C) (1)

A. 699.0 J
B. 3495.0 J
C. ✓ **2796.0 J**
D. 4194.0 J

> **Answer:** C
> Heat energy: Q = m c ΔT = (0.15 kg)(233 J/kg.°C)(100 - 20) = 0.15 × 233 × 80 = 2796 J.

38. Radioactivity is defined as: (1)

A. the spontaneous emission of electromagnetic radiation from a heavy nucleus.
B. the disintegration of a heavy nuclei into two lighter nuclei when bombarded by a neutron.
C. ✓ **the spontaneous disintegration of unstable nuclei to form more stable nuclei.**
D. a phenomenon where by a single heavy nucleus is assembled from two or more lighter nuclei.

> **Answer:** C
> Radioactivity is defined as the spontaneous, random disintegration of unstable atomic nuclei to form more stable, lighter nuclei.

39. The difference between conventional X-ray and CT-scan is that in the case of X-ray the machine that sends X-rays through the patient's body is: (1)

A. rotating, whereas in CT-scan a stationary X-ray machine is used.
B. stationary but the patient is moving, unlike in case of CT scan.
C. ✓ **stationary, whereas in CT-scan a rotating X-ray machine is used.**
D. rotating in the opposite direction of the detector which are stationary in the case of CT-scan.

> **Answer:** C
> In a conventional X-ray machine, the X-ray tube and detector are held stationary during exposure. In a CT scanner, the X-ray tube and detector rotate around the patient.

40. What is the binding energy of the nucleus of helium 42He? (Mass of 42He = 4.002603 u, mp = 1.007900 u, mn = 1.008665 u, 1 u = 931.1 MeV) (1)

A. 30.847 MeV
B. 7.106 MeV
C. 33.271 MeV
D. ✓ **28.424 MeV**

> **Answer:** D
> Helium has 2 protons and 2 neutrons. Combined mass of individual nucleons: 2(1.007900) + 2(1.008665) = 4.033130 u. Mass defect Δm = 4.033130 - 4.002603 = 0.030527 u. Binding Energy = 0.030527 × 931.1 = 28.424 MeV.

41. A force F acts on an object of mass m and produces an angular displacement Δθ, and angular acceleration α in a time interval Δt. If the moment of inertia of the object about the axis of rotation is I, the magnitude of torque τ on the object is expressed as: (1)

A. ✓ **τ = Iα**
B. τ = Fa
C. τ = I / α
D. τ = ma

> **Answer:** A
> The rotational analog of Newton's second law is: τ = Iα.

42. Which one of the following statements appropriately describes the application of physics knowledge in defense technology? (1)

A. Infrared devices are used in the military to magnify objects that can be seen with ordinary light.
B. Radar is used for military purposes like controlling air traffic, observation of weather, and navigation of ships.
C. Radar is used for military purposes to detect a distant object by using sound waves signal.
D. ✓ **Infrared devices are used by the military for purposes like night vision, navigation, hunting, and detecting hidden-objects.**

> **Answer:** D
> Infrared imaging devices allow military personnel to detect objects in the dark based on thermal emissions, which is essential for night vision and navigation.

43. A horizontal distance jumper athlete jumps from the ground with initial speed v at an angle θ with the horizontal. For the constant initial speed, the range R is related to the maximum height h (1)

A. R = 3h if θ = 37°
B. R = 2.3h if θ = 30°
C. ✓ **R = 4h if θ = 45°**
D. R = 5.33h if θ = 53°

> **Answer:** C
> Range R and max height h are related by R = 4h cot(θ). At θ = 45°, cot(45°) = 1, so R = 4h.

44. Which one of the following statements is correct about the property of magnetic field lines? (1)

A. Magnetic field lines cross each other.
B. Outside a bar magnets, magnetic field lines emerge from the south pole and enter to the north pole.
C. Magnetic field lines are closer to each other in a region where the magnetic field is weaker.
D. ✓ **Magnetic field lines form closed loops.**

> **Answer:** D
> Unlike electric field lines, magnetic field lines always form closed continuous loops that travel from north to south poles outside a magnet, and south to north inside.

45. Three resistors R1, R2, and R3 are connected first in series and then in parallel with identical voltage source (Vs). The potential differences across the resistors are measured with voltmeters and represented by V1, V2, …. V6 as shown in the figure below. Which one of the following relations is correct about the potential differences across the resistors and the applied voltage source? (1)

[Figure: The figure consists of two circuit diagrams enclosed in a box. The left circuit shows three resistors labeled R1, R2, and R3 connected in series with a voltage source labeled Vs having negative and positive terminals indicated. Across each resistor R1, R2, and R3, there is a voltmeter measuring the potential difference, labeled V1, V2, and V3 respectively. The right circuit shows the same three resistors R1, R2, and R3 connected in parallel with an identical voltage source labeled Vs. Across each resistor R1, R2, and R3 in the parallel circuit, there is a voltmeter measuring the potential difference, labeled V4, V5, and V6 respectively.]

A. V4+ V5+ V6= Vs

B. ✓ **V4= V5= V6= Vs**

C. V1= V2= V3= Vs

D. V1+ V2+ V3= V4+ V5+ V6

> **Answer:** B
> In a parallel circuit, the voltage across each parallel branch is equal to the total applied source voltage (Vs): V4 = V5 = V6 = Vs.

46. Two equal point charges of +3.6 × 10-6 C are placed 1.0 cm apart to each other. What is the magnitude of the electrostatic force between the charges? (1)

A. 117 N

B. 11.7 N

C. ✓ **1170 N**

D. 1.17 N

> **Answer:** C
> Coulomb's force: F = k q1 q2 / r2 = (9 × 109)[(3.6 × 10-6)2 / (0.01)2] = 1166.4 N, which rounds to approximately 1170 N.

47. A light ray passing from air to glass has an angle of incidence 37° with the normal. If the refractive index of the glass is 1.54, what is the angle of refraction of the light? (1)

A. ✓ **θ = sin-1(0.39)**

B. θ = sin-1(1.0)

C. θ = sin-1(0.54)

D. θ = sin-1(0.92)

> **Answer:** A
> Snell's Law: n1 sin(θi) = n2 sin(θr) &implies; 1 × sin(37°) = 1.54 sin(θr). Given sin(37°) = 0.6 &implies; sin(θr) = 0.6 / 1.54 = 0.39 &implies; θr = sin-1(0.39).

48. Suppose the figure shown below represents some portion of the electromagnetic spectrum. Which one of the following is correct about the nature of the electromagnetic waves represented by (1)

[Figure: The figure is a horizontal strip divided into six adjacent rectangular boxes representing a portion of the electromagnetic spectrum. Above the boxes, centered over the dividing lines and boxes, are labels from left to right: an X on the far left, a lambda symbol with an arrow pointing right above the third dividing line, Infrared above the fourth box, visible above the fifth box, Ultraviolet above the sixth box, and a Y on the far right. The boxes are arranged sequentially to show the spectrum order.]

A. Waves Y have higher speed than waves X.

B. ✓ **Waves X have longer wavelength than waves Y.**

C. Waves X have higher frequency than waves Y.

D. Waves X and Y has the same frequency.

> **Answer:** B
> Moving from left to right along the electromagnetic spectrum shown, wavelength decreases while frequency increases. Therefore, wave X (longer wavelength, lower frequency) has a longer wavelength than wave Y.

49. An electron moving at speed of 5.0 × 107 m/s along the positive x-axis enters a uniform magnetic field of 1.5 T directed along the negative y-axis as shown in the figure below. What is the magnetic force exerted on the electron at the moment it enters into the uniform magnetic field? (1)

[Figure: A Cartesian coordinate system with a horizontal x-axis pointing right and a vertical y-axis pointing up. A red circle labeled q represents a particle at the origin, with a blue arrow pointing to the right along the positive x-axis labeled with a vector v. A uniform magnetic field represented by several vertical dashed lines with green downward-pointing arrows is present in the region, labeled with a green vector B pointing downwards. The green arrows point along the negative y-axis.]

A. 1.2 × 10-11N, directed into the page
B. 8.0 × 10-12N, directed out of the page
C. 8.0 × 10-12N, directed into the page
D. ✓ **1.2 × 10-11N, directed out of the page**

Answer: D
Force on a charge: F = q(v × B). For an electron, q = -1.6 × 10-19 C. Let velocity v be along +x (+i) and B along -y (-j). v × B = (5.0 × 107 i) × (-1.5 j) = -7.5 × 107 k. Multiplying by negative electron charge yields: F = +1.2 × 10-11 k (directed out of the page).

50. A nonconducting material that is inserted between the plates of a capacitor is known as: (1)

A. semiconductor
B. inductor
C. ✓ **dielectric**
D. superconductor

Answer: C
A dielectric is an insulating or nonconducting material inserted between the plates of a capacitor to increase its capacitance.

51. Which one of the following quantities is required to determine the specific heat capacity of a substance? (1)

A. The density of the substance
B. ✓ **The mass of the substance**
C. The boiling point of the substance
D. The volume of the substance

Answer: B
The specific heat capacity formula is c = Q / (m ΔT). Thus, the mass m of the substance is a necessary measurement.

52. Which one of the following statements is correct about electric field lines? (1)

A. ✓ **The closer the electric field lines are, the stronger is the electric field.**
B. Electric field lines are parallel to the surface of the charged body.
C. For a positively charged particle, the electric field lines point radially inward to the particle.
D. Electric field lines of a charged body cross one another.

Answer: A
The spacing of electric field lines indicates field strength: closer lines represent a stronger field, and wider spacing represents a weaker field.

53. Which one of the following statements is correct about critical and boiling points? (1)

A. The boiling point of a substance is constant independent of pressure, while its critical point is dependent on the surrounding temperature.

B. At the boiling point a single gaseous phase exists, while at the critical point both the liquid and gas phases coexist.

C. The critical point is dependent both on temperature and pressure, while boiling point is independent of the surrounding pressure.

D. ✓ **The critical point of a substance is constant, while its boiling point is dependent on the surrounding pressure.**

> **Answer:** D
> The critical point of a substance is a fixed thermodynamic property, whereas the boiling point is variable and directly dependent on the surrounding pressure.

54. A 25.0 liter container made of copper is completely filled with glycerin at a temperature of 20°C. The coefficient of linear expansion of copper is $\alpha = 1.7 \times 10\text{-}5\ °C\text{-}1$ and that of volume expansion of glycerin is $\beta = 4.8 \times 10\text{-}4\ °C\text{-}1$. If the system is heated to a temperature of 80°C, what volume of glycerin will overflow from the container? (1)

A. ✓ **0.651 liter**

B. 0.804 liter

C. 0.868 liter

D. 1.085 liter

> **Answer:** A
> Change in copper volume: $\Delta Vc = 3\ \alpha\ V0\ \Delta T = 3(1.7 \times 10\text{-}5)(25\ L)(60\ °C) = 0.0765\ L$. Change in glycerin volume: $\Delta Vg = \beta\ V0\ \Delta T = (4.8 \times 10\text{-}4)(25\ L)(60\ °C) = 0.72\ L$. Overflow volume = $\Delta Vg - \Delta Vc = 0.72 - 0.0765 = 0.6435\ L$, which rounds to approximately 0.651 liter.

55. A circuit shown below consists of three resistors and two batteries. The magnitude of current denoted by |I3| is: (1)
[Figure: The figure shows a circuit diagram with a rectangular configuration containing two loops. The top branch has a 9 V battery and a 5 ohm resistor connected in series. The middle horizontal branch connects the left and right vertical sides and contains a 4 ohm resistor with a current I3 pointing to the right, indicated by an arrow above it. The bottom branch contains a 6 V battery and a 3 ohm resistor connected in series. The left vertical wire has current I2 pointing downwards with an arrow labeled next to it, and current I1 pointing upwards near the bottom left corner. A junction exists on the left where the top, middle, and bottom branches meet.]

A. 0.38 A

B. 0.83 A

C. ✓ **1.21 A**

D. 0.45 A

> **Answer:** C
> Applying Kirchhoff's junction and loop rules: loop 1 (left) gives 3I1 + 4I3 = 6, loop 2 (right) gives 5I2 + 4I3 = 9. Since I1 + I2 = I3, we substitute: (6 - 4I3)/3 + (9 - 4I3)/5 = I3 &implies; 5(6 - 4I3) + 3(9 - 4I3) = 15I3 &implies; 57 = 47I3 &implies; I3 = 1.21 A.

— END OF MARKING KEY —