

BITSAT 2023 May 24 Shift 1 Question Paper with Solutions

Time Allowed :3 Hours	Maximum Marks :390	Total Questions :130
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General Instructions

1. The examination is conducted in **Computer-Based Test (CBT)** mode. All questions will appear on the computer screen.
2. The total duration of the examination is **3 hours**. No extra time will be granted under any circumstances.
3. The question paper consists of **Multiple Choice Questions (MCQs)**, each having four options with only one correct answer.
4. Candidates must read each question carefully before selecting the answer. Answers can be changed only within the allotted test duration.
5. The examination follows a **negative marking scheme**. Marks will be deducted for incorrect answers, while unattempted questions will not carry any penalty.
6. Use of **calculators, mobile phones, smart watches, Bluetooth devices, or any other electronic gadgets** is strictly prohibited inside the examination hall.
7. Rough work must be done only on the rough sheets provided at the test center. These sheets must be returned after the examination.
8. Candidates must ensure that they have logged in using the correct credentials. Any discrepancy should be reported immediately to the invigilator.
9. No candidate will be allowed to leave the examination hall before the completion of the test duration.
10. Candidates must maintain discipline and follow all **instructions given by the invigilators**.
11. Any form of **unfair means, impersonation, or misconduct** will lead to immediate disqualification.
12. In case of any technical issue during the examination, candidates should remain seated and inform the invigilator without panic.

1. If an object of mass m is given a velocity equal to twice the escape velocity of Earth then the velocity of the object at the point where Earth shows no Gravitational force strength would be at?

Correct Answer: $\sqrt{3}v_e$

Solution:**Step 1: Understanding the Concept:**

The velocity at a point where Earth shows "no gravitational force strength" refers to the velocity of the object at an infinite distance ($r \rightarrow \infty$) from Earth.

To solve this, we apply the Principle of Conservation of Mechanical Energy.

The total energy at the Earth's surface must equal the total energy at infinity.

Step 2: Key Formula or Approach:

1. Conservation of Energy: $KE_{surface} + PE_{surface} = KE_{\infty} + PE_{\infty}$
2. Escape Velocity: $v_e = \sqrt{\frac{2GM}{R}}$, which implies $\frac{GM}{R} = \frac{1}{2}v_e^2$.
3. Potential Energy at surface: $U_s = -\frac{GMm}{R}$.
4. Potential Energy at infinity: $U_{\infty} = 0$.

Step 3: Detailed Explanation:

Let the initial velocity be $v = 2v_e$.

At the surface of the Earth:

$$KE_s = \frac{1}{2}m(2v_e)^2 = \frac{1}{2}m(4v_e^2) = 2mv_e^2$$

$$PE_s = -\frac{GMm}{R}$$

Since $v_e^2 = \frac{2GM}{R}$, we can write $\frac{GM}{R} = \frac{v_e^2}{2}$.

Substituting this into the potential energy equation:

$$PE_s = -m \left(\frac{v_e^2}{2} \right) = -\frac{1}{2}mv_e^2$$

At infinity:

$$KE_{\infty} = \frac{1}{2}mv_{\infty}^2$$

$$PE_{\infty} = 0$$

Applying conservation of energy:

$$2mv_e^2 - \frac{1}{2}mv_e^2 = \frac{1}{2}mv_{\infty}^2 + 0$$

$$\frac{3}{2}mv_e^2 = \frac{1}{2}mv_{\infty}^2$$

$$3v_e^2 = v_{\infty}^2$$

$$v_{\infty} = \sqrt{3}v_e$$

Step 4: Final Answer:

The velocity of the object at the point where Earth's gravitational force is zero (infinity) is $\sqrt{3}v_e$.

💡 Quick Tip

For any projectile fired with velocity $v > v_e$, the terminal velocity at infinity is always $v_\infty = \sqrt{v^2 - v_e^2}$.
In this case, $\sqrt{(2v_e)^2 - v_e^2} = \sqrt{4v_e^2 - v_e^2} = \sqrt{3}v_e$.

2. Photochemical smog pollutants cannot be reduced by?

Correct Answer: Increasing the combustion of fossil fuels

Solution:

Step 1: Understanding the Concept:

Photochemical smog is a type of air pollution formed by the reaction of sunlight with pollutants like nitrogen oxides (NO_x) and volatile organic compounds (VOCs).

To reduce smog, we must reduce the emission of these primary precursors or use biological methods to absorb them.

Step 2: Detailed Explanation:

1. **Catalytic Converters:** These are installed in vehicles to convert harmful gases like nitrogen oxides into harmless nitrogen and oxygen, directly reducing the precursors of smog.
2. **Plantation:** Certain plants such as *Pinus*, *Juniparus*, *Quercus*, *Pyrus*, and *Vitis* have the ability to metabolize and absorb nitrogen oxides, thereby helping in the reduction of photochemical smog.
3. **Clean Fuels:** Using LPG and CNG reduces the emission of hydrocarbons and particulate matter compared to traditional fuels like petrol or diesel.
4. **Combustion of Fossil Fuels:** Increasing the burning of fossil fuels releases **more** nitrogen oxides and hydrocarbons into the atmosphere, which **promotes** the formation of photochemical smog rather than reducing it.

Step 3: Final Answer:

Increasing the combustion of fossil fuels is a cause of pollution and cannot be a method to reduce photochemical smog.

💡 Quick Tip

Photochemical smog is also known as "Los Angeles Smog" and it is oxidizing in nature. Its primary components are Ozone (O_3), PAN (Peroxyacetyl nitrate), and Nitric Oxide (NO).

3. The statement "velocity and acceleration always act through the same straight line, either in the same or opposite direction" applies for which dimensional motions?

Correct Answer: One-dimensional motion

Solution:

Step 1: Understanding the Concept:

In physics, the dimensionality of motion is determined by the number of coordinates required to describe the position of the object over time.

The relative direction of velocity ($\vec{v}$) and acceleration ($\vec{a}$) vectors determines the nature of the path.

Step 2: Detailed Explanation:

1. **One-Dimensional (1D) Motion:** In 1D motion, the object moves along a single straight line (e.g., the x-axis).

Consequently, the velocity vector must lie along this line.

Since acceleration is the rate of change of velocity ($\vec{a} = \frac{d\vec{v}}{dt}$), it must also act along the same line.

The angle between $\vec{v}$ and $\vec{a}$ can only be 0° (same direction/speeding up) or 180° (opposite direction/slows down).

2. **Two-Dimensional (2D) Motion:** In projectile or circular motion, the acceleration vector can be at any angle to the velocity vector.

For example, in uniform circular motion, acceleration is perpendicular to velocity.

3. **Three-Dimensional (3D) Motion:** Similar to 2D, the vectors can have any spatial orientation.

Step 3: Final Answer:

The condition that velocity and acceleration always act on the same straight line is only strictly true for one-dimensional motion.

💡 Quick Tip

If the angle between velocity and acceleration is constant and non-zero (like in projectile motion), the path will be a parabola.

If the angle is 0° or 180° , the path is always a straight line.

4. Two inductors each of 50mH are connected in parallel, what is the equivalent inductance?

Correct Answer: 25 mH

Solution:**Step 1: Understanding the Concept:**

Inductors in a circuit behave similarly to resistors when connected in series or parallel (assuming no mutual inductance between them).

Step 2: Key Formula or Approach:

The formula for equivalent inductance (L_{eq}) for two inductors L_1 and L_2 in parallel is:

$$\frac{1}{L_{eq}} = \frac{1}{L_1} + \frac{1}{L_2}$$

Or, for two inductors:

$$L_{eq} = \frac{L_1 \times L_2}{L_1 + L_2}$$

Step 3: Detailed Explanation:

Given:

$$L_1 = 50 \text{ mH}$$

$$L_2 = 50 \text{ mH}$$

Since both inductors are equal, the equivalent inductance is half of one inductor:

$$L_{eq} = \frac{50 \times 50}{50 + 50}$$

$$L_{eq} = \frac{2500}{100}$$

$$L_{eq} = 25 \text{ mH}$$

Step 4: Final Answer:

The equivalent inductance of two 50 mH inductors in parallel is 25 mH.

 Quick Tip

For n identical inductors in parallel, the equivalent inductance is $L_{eq} = \frac{L}{n}$.
For n identical inductors in series, it is $L_{eq} = nL$.

5. Conservation of linear momentum is a necessary condition for which Kepler's laws?

- (A) Kepler's First Law
- (B) Kepler's Second Law
- (C) Kepler's Third Law
- (D) None of these

Correct Answer: (D) None of these

Solution:**Step 1: Understanding the Concept:**

Kepler's laws describe the motion of planets around the Sun under the influence of gravitational force.

A central force is a force that is always directed towards or away from a fixed point (the center) and whose magnitude depends only on the distance from that center.

In the Sun-Planet system, gravity acts as a central force directed towards the Sun.

Step 2: Key Formula or Approach:

1. Newton's Second Law in terms of momentum: $\vec{F} = \frac{d\vec{p}}{dt}$.
2. Torque definition: $\vec{\tau} = \vec{r} \times \vec{F}$.
3. Angular Momentum definition: $\vec{L} = \vec{r} \times \vec{p}$.
4. Relation between Torque and Angular Momentum: $\vec{\tau} = \frac{d\vec{L}}{dt}$.

Step 3: Detailed Explanation:

For a planet orbiting the Sun:

1. **Linear Momentum ($\vec{p}$):** Linear momentum is given by $\vec{p} = m\vec{v}$.

Since a net gravitational force $\vec{F}_g$ acts on the planet, $\frac{d\vec{p}}{dt} = \vec{F}_g \neq 0$.

As the planet moves in an elliptical orbit, its velocity direction and magnitude change constantly. Therefore, linear momentum is **not conserved**.

2. **Angular Momentum ($\vec{L}$):** The gravitational force is a central force, meaning $\vec{F}_g$ is parallel to the radius vector $\vec{r}$.

The torque $\vec{\tau} = \vec{r} \times \vec{F}_g = rF_g \sin(180^\circ) = 0$.

Since the torque is zero, the angular momentum $\vec{L}$ is constant ($\frac{d\vec{L}}{dt} = 0$).

3. **Kepler's Second Law (Law of Areas):** This law states that a line segment joining a planet and the Sun sweeps out equal areas during equal intervals of time.

This is a direct mathematical consequence of the **conservation of angular momentum**, not linear momentum.

4. **Kepler's First and Third Laws:** These laws are derived using the inverse-square nature of the gravitational force and the conservation of energy and angular momentum.

Step 4: Final Answer:

None of Kepler's laws are based on the conservation of linear momentum of the planet.

If the question intended to ask about "Angular Momentum," the answer would be the Second Law.

However, based on the literal text "linear momentum," the correct choice is "None of these."

💡 Quick Tip

Always distinguish between Linear and Angular momentum in orbital mechanics.

In any central force motion (like gravity):

1. Linear Momentum is NOT conserved (direction of velocity changes).
2. Angular Momentum IS conserved (torque is zero).
3. Kepler's 2nd Law is equivalent to the Conservation of Angular Momentum.

6. The Radial Probability curve for 2s orbital.

Correct Answer: Shows two peaks with one radial node

Solution:

Step 1: Understanding the Concept:

The radial probability distribution function $4\pi r^2 R^2(r)$ represents the probability of finding an electron at a distance r from the nucleus.

The number of radial nodes for any orbital is given by the formula:

$$\text{Radial Nodes} = n - l - 1$$

Step 2: Detailed Explanation:

1. For the 2s orbital:

Principal quantum number $n = 2$.

Azimuthal quantum number $l = 0$ (for s-orbitals).

2. Calculate radial nodes:

$$\text{Nodes} = 2 - 0 - 1 = 1$$

3. **Curve Characteristics:**

- Because there is one radial node, the curve must touch the x-axis (probability = 0) exactly once at a specific distance from the nucleus (excluding $r = 0$ and $r = \infty$).
- The curve starts at 0 (at the nucleus, $r = 0$, the factor r^2 makes the radial probability zero).
- It rises to a small first peak, drops to zero at the radial node, and then rises to a larger second peak before asymptotically approaching zero at large distances.

Step 3: Final Answer:

The radial probability curve for the 2s orbital is characterized by having two humps (peaks) and one radial node.

💡 Quick Tip

Radial Probability Distribution ($4\pi r^2 \psi^2$) always starts from 0 at the nucleus.
Radial Density (ψ^2) for s-orbitals, however, starts at a maximum value at the nucleus.
Do not confuse the two!

7. How many elements are there in period 4 of the periodic table?

Correct Answer: 18

Solution:

Step 1: Understanding the Concept:

The number of elements in a period corresponds to the maximum number of electrons that can be accommodated in the shells being filled in that period according to the Aufbau principle.

Step 2: Detailed Explanation:

1. In the 4th period, the energy levels being filled are the 4s, 3d, and 4p subshells.
2. Capacity of subshells:
 - 4s subshell: 2 electrons (2 elements: K, Ca)
 - 3d subshell: 10 electrons (10 elements: Sc to Zn)
 - 4p subshell: 6 electrons (6 elements: Ga to Kr)
3. Total number of elements = $2 + 10 + 6 = 18$.
4. The period starts with Potassium ($Z = 19$) and ends with Krypton ($Z = 36$).

Step 3: Final Answer:

There are 18 elements in the 4th period of the modern periodic table.

💡 Quick Tip

Periods 1, 2, 3, 4, 5, 6, 7 contain 2, 8, 8, 18, 18, 32, 32 elements respectively.
Period 4 is the first period to include the transition metals (d-block).

8. If a block is pushed upwards on an inclined plane with velocity v and then it comes back to the initial position, then its velocity is

- (A) equal to v
- (B) more than v
- (C) less than v

(D) more or less than v depending on the angle of the inclined plane.

Correct Answer: (C) less than v

Solution:

Step 1: Understanding the Concept:

This problem involves the Work-Energy Theorem and the concept of non-conservative (dissipative) forces.

When a block moves on an inclined plane, friction always acts in a direction opposite to the motion.

Since friction is a non-conservative force, it performs negative work throughout the entire trip (both upwards and downwards).

Step 2: Key Formula or Approach:

1. Law of Conservation of Energy (in the presence of friction):

$$E_{initial} = E_{final} + |W_{friction}|$$

2. Velocity-Energy relation: $KE = \frac{1}{2}mv^2$.

Step 3: Detailed Explanation:

Let the initial point be A and the highest point reached be B.

As the block moves from A to B (upwards), work is done against gravity and friction.

As the block moves from B back to A (downwards), gravity does positive work, but friction again does negative work (as it now acts upwards).

Total work done by friction over the complete round trip is negative:

$$W_{f,total} = W_{f,up} + W_{f,down} < 0$$

According to the Work-Energy Theorem:

$$\Delta KE = W_{net}$$

$$KE_{final} - KE_{initial} = W_{gravity,total} + W_{friction,total}$$

Since the block returns to the same height, the net work done by gravity (a conservative force) is zero ($W_{gravity,total} = 0$).

Thus, $KE_{final} - KE_{initial} = W_{friction,total}$.

Since $W_{friction,total}$ is negative:

$$KE_{final} < KE_{initial}$$

$$\frac{1}{2}mv_{final}^2 < \frac{1}{2}mv_{initial}^2$$

$$v_{final} < v$$

Step 4: Final Answer:

Because energy is lost due to friction during the motion, the return velocity is less than the initial velocity v .

 Quick Tip

In the absence of friction (smooth plane), the velocity would be equal to v .
In any real-world scenario involving sliding friction, the final speed is always less than the initial speed because mechanical energy is converted into heat.

9. If gamma (C_p/C_v) of a gas is 1.5, then in an adiabatic process what would be the relation between T and V?

Correct Answer: $TV^{0.5} = \text{constant}$

Solution:

Step 1: Understanding the Concept:

In an adiabatic process, there is no heat exchange between the system and its surroundings ($q = 0$).

The state variables P , V , and T follow specific relations governed by the adiabatic index γ .

Step 2: Key Formula or Approach:

The Poisson's relations for an adiabatic process are:

1. $PV^\gamma = \text{constant}$
2. $TV^{\gamma-1} = \text{constant}$
3. $P^{1-\gamma}T^\gamma = \text{constant}$

Step 3: Detailed Explanation:

We are given the adiabatic index:

$$\gamma = 1.5$$

We need the relationship between Temperature (T) and Volume (V).

Using the formula:

$$TV^{\gamma-1} = \text{constant}$$

Substitute the value of γ :

$$TV^{1.5-1} = \text{constant}$$

$$TV^{0.5} = \text{constant}$$

Alternatively, this can be written as $T\sqrt{V} = \text{constant}$.

Step 4: Final Answer:

The relation between T and V for the given gas is $TV^{0.5} = \text{constant}$.

 Quick Tip

Remember that γ is always greater than 1 for all gases.
For monoatomic gases $\gamma = 1.67$, and for diatomic gases $\gamma = 1.4$.
A value of $\gamma = 1.5$ corresponds to a gas with specific degrees of freedom (like some triatomic non-linear gases or specific mixtures).

10. An acid has $\text{pH} = 4$ and $\text{p}K_a = 5$, what would be the initial concentration of the acid.

Correct Answer: $1.1 \times 10^{-3} \text{ M}$

Solution:

Step 1: Understanding the Concept:

This problem involves the dissociation of a weak acid (HA).

The pH provides the concentration of hydrogen ions ($[H^+]$), and $\text{p}K_a$ provides the acid dissociation constant (K_a).

Step 2: Key Formula or Approach:

1. $[H^+] = 10^{-\text{pH}}$

2. $K_a = 10^{-\text{p}K_a}$

3. Dissociation equilibrium: $K_a = \frac{[H^+][A^-]}{[HA]}$

For a weak acid, $[H^+] = [A^-]$, and if C is the initial concentration, then at equilibrium $[HA] = C - [H^+]$.

So, $K_a = \frac{[H^+]^2}{C - [H^+]}$.

Step 3: Detailed Explanation:

From the given data:

$$[H^+] = 10^{-4} \text{ M}$$

$$K_a = 10^{-5}$$

Substitute these into the equilibrium expression:

$$10^{-5} = \frac{(10^{-4})^2}{C - 10^{-4}}$$

$$10^{-5} = \frac{10^{-8}}{C - 10^{-4}}$$

Rearranging to solve for C :

$$C - 10^{-4} = \frac{10^{-8}}{10^{-5}}$$

$$C - 10^{-4} = 10^{-3}$$

$$C = 10^{-3} + 10^{-4}$$

$$C = 0.001 + 0.0001$$

$$C = 0.0011 \text{ M} = 1.1 \times 10^{-3} \text{ M}$$

Step 4: Final Answer:

The initial concentration of the acid is $1.1 \times 10^{-3} \text{ M}$.

💡 Quick Tip

If $C \gg [H^+]$, we often simplify the formula to $[H^+] = \sqrt{K_a C}$.

However, when K_a and $[H^+]$ are close in magnitude (as in this case, 10^{-5} vs 10^{-4}), the dissociation is significant and you must use the full expression $C = \frac{[H^+]^2}{K_a} + [H^+]$.

11. What would be the reaction between B and $LiAlH_4$

Correct Answer: Reaction with Boron Trihalide to produce Diborane

Solution:

Step 1: Understanding the Concept:

Lithium Aluminium Hydride ($LiAlH_4$) is a powerful reducing agent.

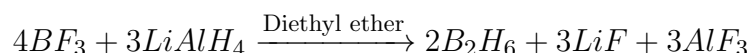
In inorganic chemistry, it is commonly used to prepare hydrides of p-block elements by reacting with their halides.

Step 2: Detailed Explanation:

The "B" in the question context usually refers to Boron compounds, specifically Boron trihalides like BF_3 or BCl_3 .

When Boron trifluoride (BF_3) reacts with $LiAlH_4$ in ether, it produces Diborane (B_2H_6).

The balanced chemical equation is:



This is a standard laboratory method for the preparation of Diborane.

Step 3: Final Answer:

The reaction between Boron halides and $LiAlH_4$ results in the formation of Diborane (B_2H_6).

💡 Quick Tip

Diborane is a toxic, highly reactive gas that catches fire spontaneously in air. It contains unique "3-center-2-electron" bonds, often called banana bonds.

12. If points $A(x_1, y_1, z_1)$, $B(x_2, y_2, z_2)$, $C(x_3, y_3, z_3)$ are collinear then in which ratio does B divide AC?

Correct Answer: $(x_2 - x_1) : (x_3 - x_2)$

Solution:

Step 1: Understanding the Concept:

When three points are collinear, one point divides the segment formed by the other two in a specific ratio.

We use the section formula to find this ratio.

Step 2: Key Formula or Approach:

Let point B divide the segment AC in the ratio $k : 1$.

The coordinates of point $B(x_2, y_2, z_2)$ are given by:

$$x_2 = \frac{kx_3 + 1 \cdot x_1}{k + 1}$$

Step 3: Detailed Explanation:

From the x-coordinate formula:

$$x_2(k + 1) = kx_3 + x_1$$

$$kx_2 + x_2 = kx_3 + x_1$$

Group the terms containing k :

$$kx_2 - kx_3 = x_1 - x_2$$

$$k(x_2 - x_3) = x_1 - x_2$$

$$k = \frac{x_1 - x_2}{x_2 - x_3}$$

Alternatively, multiplying both numerator and denominator by -1 :

$$k = \frac{x_2 - x_1}{x_3 - x_2}$$

The ratio $k : 1$ is therefore $(x_2 - x_1) : (x_3 - x_2)$.

Step 4: Final Answer:

Point B divides AC in the ratio $(x_2 - x_1) : (x_3 - x_2)$.

 Quick Tip

The same ratio can be calculated using y-coordinates $(y_2 - y_1) : (y_3 - y_2)$ or z-coordinates $(z_2 - z_1) : (z_3 - z_2)$.

If the calculated ratio is positive, the division is internal; if negative, the division is external.

13. Odd one out: red, yellow, green, pink.

Correct Answer: pink

Solution:

Step 1: Understanding the Concept:

Odd-one-out questions require finding a common property shared by three items that the fourth item lacks.

Step 2: Detailed Explanation:

1. **Spectral Colors:** Red, Yellow, and Green are all primary or secondary colors found in the visible light spectrum (VIBGYOR: Violet, Indigo, Blue, Green, Yellow, Orange, Red).

2. **Pink:** Pink is not a spectral color; it does not correspond to a single wavelength of light. It is a "non-spectral" color formed by mixing red and violet/blue light.
3. **Traffic Lights:** Red, Yellow (Amber), and Green are the standard colors used in traffic signals worldwide. Pink is not used.

Step 3: Final Answer:

Pink is the odd one out because it is not part of the standard visible spectrum (rainbow colors) or traffic light colors.

 Quick Tip

Always look for scientific groupings first (like the VIBGYOR spectrum) before looking for everyday functional groupings (like traffic lights).

14. Odd one out: saturday, monday, tuesday, thursday

Correct Answer: saturday

Solution:

Step 1: Understanding the Concept:

Identify the common classification for the days of the week provided.

Step 2: Detailed Explanation:

1. **Weekdays vs. Weekends:** Monday, Tuesday, and Thursday are standard "weekdays" or working days in a typical work week.
2. **Saturday:** Saturday is classified as a "weekend" day.
3. **Linguistic check:** Monday, Tuesday, and Thursday have 6, 7, and 8 letters respectively. Saturday has 8 letters. There is no strong pattern in length.
4. **Starting letters:** M, T, T, S. No obvious single outlier here other than S being the only weekend day starter.

Step 3: Final Answer:

Saturday is the odd one out because it is a weekend day, while the others are weekdays.

 Quick Tip

In reasoning, most "days of the week" odd-one-out questions revolve around the Week-day vs. Weekend distinction.