Chapter 5: Work and Kinetic Energy

Short Questions with Answers

Q.1: Is it possible that a force is acting on a body and the body is in motion due to this force, but the work done after certain time is zero?

Answer: Conditions for Zero Work Despite Force and Motion

Yes, it is possible in the following cases:

1. Circular Motion (Conservative Force in Closed Path):

In a circular motion, centripetal force acts towards the center.

The displacement is tangential, hence perpendicular to the force.

So, no work is done by centripetal force as $W = Fd \cos(90°) = 0$.

2. Horizontal Motion Under Gravity:

When an object moves horizontally, gravity acts vertically downward.

Since force and displacement are perpendicular, no work is done by gravity.

Q.2: Some non-conservative forces are acting on a body. Can they change the total mechanical energy of the body?

Answer: Effect of Non-Conservative Forces on Mechanical Energy

Yes, non-conservative forces can change the total mechanical energy of a body.

Examples of Non-Conservative Forces:

- Friction
- Air resistance
- Applied forces

Explanation:

- These forces are path-dependent.
- They often convert mechanical energy into other forms, such as heat or sound.
- Mechanical energy is not conserved when non-conservative forces are involved.

Q.3: Kinetic energy and work are related. Can kinetic energy ever be negative? Can work ever be negative?

Answer: Sign of Work and Kinetic Energy

1. Kinetic Energy (K.E.):

- K.E. is always positive.
- **Formula:** $K.E = \frac{1}{2} mv^2$
- (Both mass and square of velocity are always positive)

2. Work:

- Work can be positive, negative, or zero.
- Negative work occurs when the force acts opposite to displacement.
- Maximum negative work: when angle = 180°,
- $W = Fd \cos(180°) = -Fd$

Q.4: Differentiate between conservative and non-conservative forces.

Answer: Difference Between Conservative and Non-Conservative Forces

Conservative Forces:	Non-Conservative Forces:
Work done is path-independent.	Work done is path-dependent.
Mechanical energy is conserved.	Mechanical energy is not conserved.
Work done in a closed path is zero.	Work done in a closed path is not zero.
Potential energy can be defined.	Potential energy cannot be defined.
Force is derived from a potential energy function.	Force is not derived from a potential energy function.
Work done is reversible.	Work done is irreversible.
Examples: Gravitational force, elastic spring force.	Examples: Friction, air resistance.
Independent of the velocity of the object.	Depends on the velocity of the object.
Depends only on the position of the object.	Depends on both position and velocity of the object.

Q.5: What is the work done by the moon as it revolves around the Earth?

Answer: Work Done by the Moon During Revolution

- The gravitational force between Earth and Moon acts towards the center (Earth).
- The displacement of the moon is tangential to the orbit.
- Angle between force and displacement θ = 90°

Using formula:

$W = F \times d \times \cos(\theta)$

$W = F \times d \times \cos(90°)$

$W = F \times d \times 0 = 0$

Therefore, the work done by the moon as it revolves around the Earth is zero.

Additional Questions

Q.1: A man rowing a boat upstream is at rest with respect to shore. Is he doing work?

Answer:

No, he is not doing any work.
Reason:

The boat is at rest with respect to the shore, so the displacement is zero.

According to the formula:
$W = F \cdot d \cdot \cos\theta$
If d = 0, then W = 0, regardless of the force applied.

Q.2: When an arrow is shot from its bow, it has kinetic energy. From where does it get this energy?
Answer:
When the bow is stretched backward, elastic potential energy (EPE) is stored in the bow and arrow.

This EPE is equal to the work done to stretch the bow.

When the arrow is released, this elastic potential energy converts into kinetic energy (KE), which causes the arrow to move forward.

Q.3: A man drops a cup from a certain height, which breaks into pieces. What energy changes are involved?
Answer:
Energy changes involved are:

- Loss of gravitational potential energy.
- Gain of kinetic energy during the fall.

Upon hitting the ground, KE converts into:
1. Energy used to break the cup.
2. Sound energy.
3. Kinetic energy of scattered pieces.
4. Heat energy due to friction.

Q.4: A car is accelerated from rest to 10 m/s. Let the energy spent be E. How much energy is required to accelerate it from 10 m/s to 20 m/s?
Answer:
Initial energy (from 0 to 10 m/s):
$E = \frac{1}{2} \cdot m \cdot (10)^2 = \frac{1}{2} \cdot m \cdot 100$

For second part (from 10 to 20 m/s):
$E = \frac{1}{2} \cdot m \cdot [(20)^2 - (10)^2] = \frac{1}{2} \cdot m \cdot (400 - 100) = \frac{1}{2} \cdot m \cdot 300 = 3 \times$ initial E

So, energy required = 3E

Conclusion: Energy required from 10 m/s to 20 m/s is three times the energy required from 0 to 10 m/s.

Q.5: Show that K.E = $p^2/2m$, where p is momentum and m is mass of the body.

Answer:

We know:

K.E = $\frac{1}{2} \cdot mv^2$

Also, p = mv

So, v = p/m

Substitute in K.E formula:

K.E = $\frac{1}{2} \cdot m \cdot (p/m)^2 = \frac{1}{2} \cdot m \cdot (p^2/m^2) = p^2/2m$

Q.6: A light body and a heavy body have equal momenta. Which of the two has larger K.E? Also find the ratio of their energies.

Answer:

We know:

K.E = $p^2/2m$

If momentum is constant, then K.E is inversely proportional to mass.

So, the lighter body has greater K.E.

Ratio of their energies:

$E_1/E_2 = m_2/m_1$

Q.7: A heavy body and a light body have equal K.E. Which of the two has larger momentum?

Answer:

Given K.E = $p^2/2m$,

For same K.E, momentum $p \propto \sqrt{m}$

So, the heavier body has greater momentum.

Q.8: If momentum is increased by 20%, then find the percentage increase in K.E.

Answer:

Let initial momentum = p, final momentum = 1.2p

K.E is proportional to p^2.
So,
Initial K.E $\propto p^2$
Final K.E $\propto (1.2p)^2 = 1.44p^2$
% increase in K.E = $[(1.44p^2 – p^2)/p^2] \times 100 = 44\%$

Q.9: A meteor burns upon entering Earth's atmosphere. What happens to its energy?
Answer:
As the meteor enters the atmosphere, it faces air friction.
The kinetic energy is lost due to friction.

This lost energy is converted into:
1. Heat energy – burns the meteor.
2. Light energy – appears as a shooting star.

Q.10: A boy uses a catapult to throw a stone that smashes a greenhouse window. What are the possible energy changes?
Answer:
Energy changes involved:
Elastic potential energy in the catapult is converted to kinetic energy of the stone.

When the stone hits the glass:
1. Part of K.E. is used to break the glass.
2. Remaining energy converts into heat and sound.

Chapter 6:Fluid Mechanics

Exercise Short Questions

Q1. Why do athletes such as swimmers and bicyclists wear body suits in competition?
Answer:
Reason: When a person moves through a fluid (air or water), a drag force acts in the opposite direction.
Purpose of Body Suits: These suits reduce the exposed body area, minimizing wind and fluid resistance.

Benefits:
- Reduce drag force
- Increase speed and efficiency
- Support muscles and ensure comfort
- Provide safety and boost confidence

Q2. Distinguish between turbulent and streamline flow.
Answer:

Streamline Flow:	Turbulent Flow:
1. Flow is regular and orderly.	1. Flow is irregular and disorderly.
2. Flow lines are parallel and do not cross each other.	2. Flow lines are not parallel and can cross each other.
3. Velocity of fluid is less than the critical velocity.	3. Velocity of fluid is greater than the critical velocity.
4. All particles pass a given point with the same velocity.	4. Different particles pass a given point with different velocities.

Q3. Why does the speed of water in a river change with its width?

Answer:

Principle Involved: Equation of continuity ($A \times V$ = constant)

Explanation:

In wider regions: Area is greater, so speed is lower

In narrower regions: Area is smaller, so speed is higher

Conclusion: The flow speed increases in narrow regions and decreases in wide regions to maintain constant flow rate.

Q4. Why is it dangerous to stand near a fast-moving train?

Answer:

Principle Involved: Bernoulli's Principle

Explanation:

- Fast-moving train causes low pressure between itself and a nearby person
- Higher pressure behind the person pushes them towards the train

Conclusion: This pressure difference may cause the person to fall towards the train, making it dangerous.

Q5. Verify that pressure has units of energy per unit volume.

Answer:

Pressure: Defined as Force per unit area (N/m^2 or Pascal)

Energy per Unit Volume: Defined as Joule per cubic meter (J/m^3)

Conclusion:

1 Pascal = 1 N/m^2 = 1 J/m^3

So, pressure and energy per unit volume have the same units.

Q6. How does fluid rise in a perfume atomizer?
Answer:
Working Principle: Bernoulli's Principle

Explanation:

- Pressing the bottle sends fast-moving air through a jet, creating low pressure
- Atmospheric pressure pushes the liquid up the tube
- The liquid is sprayed as fine mist through the nozzle

Q7. Why does an empty plastic bag fly out when the window of a moving car is lowered?
Answer:
Reason:
Outside the car: Air moves fast, pressure is low
Inside the car: Air is slower, pressure is high

Conclusion: The bag moves from high-pressure (inside) to low-pressure (outside) region, so it flies out.

Q8. Explain how lift is produced on an aeroplane wing when it runs on a runway.
Answer:
Principle Involved: Bernoulli's Principle

Explanation:

- Wing shape causes air to move faster over the top than under the bottom
- Pressure is lower on top and higher underneath

Result: A net upward force (lift) is created, helping the plane to take off.

Q9. Why does blood pressure in humans increase while climbing a mountain?
Answer:

Explanation:

- At higher altitudes, atmospheric pressure decreases.
- To maintain proper blood flow and oxygen delivery, the body increases blood pressure.

Conclusion: This compensatory increase ensures adequate circulation in low-pressure environments.

Q10. Why do wings of birds and aircraft have a curved upper surface and a flat lower surface?

Answer:surface

Explanation:

Curved upper surface causes air to move faster over it than the flat lower surface.

According to Bernoulli's principle, faster airflow leads to lower pressure on top.
Result: Higher pressure under the wing creates lift, allowing birds and planes to fly.

Q11. How can the terminal velocity of a body be increased?

Answer:

Terminal Velocity Depends On:

- Mass and shape of the body
- Viscosity and density of the fluid

To Increase Terminal Velocity:

1. Use heavier or denser materials
2. Reduce the surface area (streamlined shape)
3. Reduce the fluid's viscosity

Conclusion: Terminal velocity increases with mass and decreases with surface area and fluid resistance.

Additional Questions

Q.1: Why do clouds appear to float in air?

Answer:

Reason: Clouds are composed of very small water droplets.
Effect: Due to their small mass, their terminal velocity is very low.
Conclusion: As a result, the droplets fall very slowly and appear to float in the air.

Q.2: Why do fog droplets appear to be suspended in air?

Answer:

Reason: The weight of fog droplets is extremely small.
Drag Force: The drag force acting upward quickly balances their weight.
Terminal Velocity: Their terminal velocity becomes very small.
Conclusion: They appear to remain suspended in air without falling quickly.

Q.3: Eight equal oil drops fall with a terminal velocity of 0.1 m/s. If they combine to form one big drop, what is its new terminal velocity?

Answer:

Given: Terminal velocity of each small drop = 0.1 m/s

Concept: When 8 drops combine, the radius of the big drop becomes double.

Relation: Terminal velocity ∝ (radius)^2

New Terminal Velocity:

= 4 × 0.1 m/s

= 0.4 m/s

Conclusion: Terminal velocity increases to 0.4 m/s for the combined drop.

Q.4: What happens to the water level in a capillary tube when air is blown in the horizontal pipe?

Answer:

Effect of Blowing Air: Creates low pressure in the horizontal pipe.

Pressure Difference: Liquid in the beaker is at higher pressure.

Result: Liquid rises in the capillary tube towards low pressure.

Conclusion: Water level in the capillary tube rises.

Q.5: If a stream of air is blown under one pan of a balance, will it go up or down?

Answer:

Bernoulli's Principle: Where fluid speed is high, pressure is low.

Situation: Air blown under the pan has high speed → low pressure

Pressure Difference: Upper side has higher pressure, lower side has lower pressure

Result: Net force acts downward, so the pan goes down.

Q.6: Why are house roofs often lifted during hurricanes? Why should windows be opened?

Answer:

Effect of Hurricane: Air outside moves fast → low external pressure

Inside House: Pressure is higher → pressure difference created

Result: Net upward force on roof → roof lifts

Why Open Windows: To reduce pressure difference, balancing inside and outside pressure

Conclusion: Less force acts on roof, prevents damage.

Q.7: How do we sip water through a straw? Can we do it on the moon?

Answer:

On Earth:

- Sucking air creates low pressure in mouth
- Atmospheric pressure pushes liquid up the straw

On Moon:

No atmosphere → no atmospheric pressure

Conclusion: Cannot sip water through a straw on the moon.

Q.8: Why do leaves on the road follow a fast-moving car?

Answer:
Car Movement: Creates fast airflow around the car
Pressure Difference: Pressure decreases near car, remains higher on the sides
Result: Leaves are pushed towards low pressure near the car
Conclusion: Leaves seem to follow the car.

Q.9: Why does a paper pipe squeeze when air is blown through it?

Answer:
High-Speed Air: Blown inside the pipe → low internal pressure
Outside Pressure: Atmospheric pressure remains high
Result: Net force pushes inward on the pipe
Conclusion: Paper pipe squeezes due to pressure difference.

Q.10: Why can two boats moving parallel collide?

Answer:
Speed Between Boats: Water and air move faster between the boats
Bernoulli's Principle: Fast speed → low pressure between boats
Outer Pressure: Higher than in-between
Result: Force acts from high to low pressure → boats move towards each other
Conclusion: Boats may collide due to pressure difference.

Q.11: Why does smoke rise faster in a chimney on a windy day?

Answer:
Wind Effect:
On a windy day, air flows quickly across the top of the chimney.

Bernoulli's Principle:
High-speed wind → low pressure at chimney top
Inside chimney → relatively higher pressure

Pressure Difference:
Air moves from high pressure (inside) to low pressure (outside)

Result:
Smoke is pushed upwards more rapidly

Conclusion:
Wind increases the speed of rising smoke by creating a pressure difference.

Chapter 7:Deformation Of Solids

Exercise Short Questions

Q1. Why do most solids prefer to be in the crystalline state? What is glass transition in amorphous solids?

Answer:

(a) Reason for Crystalline State:
Crystalline solids are formed when atoms are closely packed due to low intermolecular space. These strong attractive forces cause them to form an ordered, repeating structure.

Examples:
Metals like silver, copper, iron; non-metals like sulphur, iodine; and compounds like NaCl.

(b) Glass Transition:
Glass transition temperature (Tg) is the temperature at which an amorphous solid becomes soft and rubbery from a hard and brittle state.
Reason: Due to increased molecular mobility as bonding between chains becomes flexible.

Q2. Why do window glasses of old buildings show milky appearance with time?

Answer:

Reason:
Over years, due to repeated heating by sunlight and cooling at night, amorphous glass undergoes partial crystallization (annealing), leading to a milky appearance.

Q3. In an elastic body, which one is more fundamental — stress or strain?

Answer:
Stress is more fundamental.

Explanation:
Stress causes strain. Strain is the result of applied stress, hence it is derived from it. Therefore, stress is the primary/internal quantity.

Q4. Can tensile stress produce volumetric strain? Explain.

Answer:
Yes, depending on the material's Poisson's ratio (v).

- If $v = 0.5$, volumetric strain = 0 (volume remains unchanged).
- If $v < 0.5$, volume increases (positive volumetric strain).
- If $v > 0.5$, volume decreases (negative volumetric strain).

Most materials have v between 0 and 0.5, so volume usually increases.

Q5. What does the slope of a force-extension graph represent?

Answer:

The slope represents the spring constant (k) or stiffness of the material (according to Hooke's Law: F = kx).

- Greater slope → stiffer spring
- Flatter slope → more flexible spring

Q6. Is strain energy always positive? Justify.

Answer:

Yes, strain energy is always positive.

Reason:

It represents stored energy due to deformation, and since all quantities involved in its formula are positive (stress, strain, etc.), the result is always positive.

Q7. On which types of loads does the strain energy depend?

Answer:

Strain energy depends on how the load is applied:

- Gradual loading
- Sudden loading
- Impact or shock loading
- Shear loading
- Bending load

Each load type influences the energy stored differently.

Q8. Why do suspension bridges have a period of use written? Why is it dangerous after that period?

Answer:

(a) Reason:

Materials used in bridges lose strength over time due to weakening of intermolecular bonds.

(b) Effect:

Old materials can't bear the same stress; ropes may break, leading to bridge collapse.

Q9. Why do we use repeated bending to break a wire?

Answer:
Repeated bending causes elastic fatigue, weakening intermolecular bonds, and making it easier to break the wire.

Explanation:
Bending stretches and compresses parts of the wire repeatedly, weakening its structure and eventually leading to fracture.

Q10. What is the significance of modulus of elasticity?

Answer:
It determines a material's stiffness and ability to resist elastic deformation under stress.

Explanation:
A higher modulus means the material is less stretchable and more resistant to deformation.
Formula: Modulus of Elasticity = Stress / Strain

Additional Questions

Q.1 Which is more elastic: steel or rubber? Why?

Answer: Steel is more elastic than rubber.

Reason:
Elasticity is measured by the modulus of elasticity, which is the ratio of stress to strain:

☆Consider a steel wire and a rubber wire
of equal length and cross-sectional area.
☆When the same force is applied to both:

- Rubber stretches more (greater extension).
- This means rubber has more strain, so its modulus of elasticity is less.
- Since steel stretches less, it has less strain, so its modulus is higher.

Conclusion:
Since modulus of elasticity is inversely proportional to the amount of extension, steel is more elastic than rubber.

Additional Point:
Steel also returns to its original shape more quickly and can bear higher tension within its elastic limit.

Q.2 Why does the modulus of elasticity decrease as temperature increases?

Answer:
As temperature increases, the interatomic forces (the forces of attraction between atoms) weaken.

Reason:

- At higher temperatures, the vibration of atoms increases.
- This weakening of atomic bonds causes the material to become less stiff.
- For a given stress, the material will undergo more strain, meaning the modulus of elasticity (which is the ratio of stress to strain) decreases as temperature increases.

Q.3 Why are the materials used in suspension bridges given a specific lifetime? Why is it dangerous to use the bridge after that period?

Answer:

Materials used in suspension bridges have a specific lifetime because their strength to bear stress decreases over time.

Reason:

- Suspension bridges experience both tensile stresses (from cables) and compressive stresses (from towers).
- Over time, the intermolecular forces in the materials become weaker.
- As the material's strength decreases, it can no longer withstand the stresses it was originally designed to bear.
- If the material is subjected to further stress beyond its weakened state, it could fail, leading to the collapse of the bridge.

Chapter 8:Heat And Thermodynamics

Exercise Short Questions

Q.1 In 60°F (15°C), walking on the ground feels comfortable, but swimming in the ocean feels very cold. Explain.

Ans:

Heat Conductivity Difference:

Water is a much better conductor of heat than air.

As a result, water draws heat away from the body more efficiently.

Body Heat Loss:

- While walking, less body heat is lost to the air due to its poor conductivity.
- While swimming, more body heat is transferred to the water, leading to a noticeable drop in body temperature.

Conclusion:

Therefore, swimming in ocean water feels colder than walking on the ground at the same temperature.

Q.2 Do you think low temperature is the only reason for snowfall on mountains?

Ans:

Multiple Contributing Factors:

Besides low temperature, factors such as altitude, moisture, orographic lift, and precipitation play important roles.

Orographic Lift Effect:

Mountains force moist air to rise, which cools and condenses, forming clouds and eventually snow.

Conclusion:

Snowfall on mountains is not caused by temperature alone, but by a combination of climatic and geographical factors.

Q.3 Can the temperature of an isolated system change? Explain.

Ans:**Under Adiabatic Conditions:**

Yes, in adiabatic compression, temperature increases.

In adiabatic expansion, temperature decreases.

These changes occur without heat exchange (Q = 0).

Otherwise Constant:

Apart from adiabatic processes, the temperature of an isolated system remains constant.

Conclusion:

Temperature change in an isolated system is only possible during adiabatic processes.

Q.4 As a result of some process, the internal energy of a system is increased. How can one tell that the increase was due to orderly macroscopic work (W) or due to the flow of disorderly microscopic energy (Q)?

Answer:

Case 1 – Adiabatic Process (Q = 0):

If no heat is exchanged and the system is insulated, then the increase in internal energy is due to work done on the system.

Example: Compressing a gas in an insulated cylinder.

Case 2 – Isochoric Process (W = 0):

If volume is constant and no work is done, then the internal energy increases due to heat supplied.

Example: Heating gas in a rigid container.

Conclusion:
By observing the type of process (adiabatic or isochoric), one can determine the cause of internal energy increase.

Q.5 At what temperature (in °C) does the volume of a gas at 0°C become double, while pressure remains constant?
Answer:
Given:
Initial temperature = 0°C = 273 K
Final volume = 2 × Initial volume

Using Charles's Law:
V1/T1 = V2/T2
V/273 = 2V/T2
Solving: T2 = 546 K
In °C: 546 - 273 = 273°C

Conclusion:
The temperature should be 273°C for the volume to double at constant pressure.

Q.6 Work done on a system puts energy into it. Work done by a system removes energy from it. Give examples.
Answer:
Work done on a system:
Example: Compressing a gas with a piston.
Energy is added, increasing internal energy and temperature.

Work done by a system:
Example: Steam expanding in a turbine.
System does work and loses internal energy.

Conclusion:
Work on the system increases energy; work by the system decreases energy.

Q.7 Should the internal energy of a system necessarily increase if heat is added to it?
Answer:
Not always.
In isothermal processes, the temperature remains constant.
Heat added is completely used for doing work, and internal energy doesn't change.

Conclusion:
Internal energy only increases if heat is not used to do work.

Q.8 Why is the slope of the adiabatic curve steeper than the slope of the isothermal curve?

Answer:
Adiabatic Process:

- No heat exchange.
- Temperature falls rapidly with volume expansion.
- So pressure drops faster.

Isothermal Process:

- Temperature remains constant.
- Pressure drops more slowly.

Conclusion:
Adiabatic curves are steeper because they involve a quicker loss of pressure with volume increase.

Q.9 What are the limitations of the First Law of Thermodynamics?

Answer:
1. Does not indicate direction of heat flow.
2. Cannot tell whether a process is possible or not.
3. Doesn't tell how much heat is converted into work.
4. Ignores the concept of entropy.
5. Doesn't describe mechanisms of heat transfer.
6. Assumes reversibility, which is often ideal.

Q.10 What are the conditions for an isothermal process?

Answer:
1. Temperature must remain constant.
2. System must be in thermal contact with surroundings.
3. Process should be carried out very slowly.
4. Internal energy remains constant.
5. Good heat conductivity is required.

Q.11 Why are isothermal processes slow and adiabatic processes fast?

Answer:
Isothermal Process – Slow:

- Needs continuous heat exchange with surroundings.
- Takes time to maintain constant temperature.

Adiabatic Process – Fast:

- No heat exchange; temperature changes instantly.
- System must be insulated.

Conclusion:
Isothermal processes are slow due to heat exchange; adiabatic processes are fast due to insulation.

Q.12 Can a process be both adiabatic and isothermal?

Answer: No, a process cannot be both adiabatic and isothermal simultaneously.

Adiabatic Process:

- No heat exchange ($\Delta Q = 0$)
- Temperature changes as work is done

Isothermal Process:

- Temperature remains constant ($\Delta T = 0$, hence $\Delta U = 0$)
- Heat exchange occurs to maintain constant temperature

Explanation:
According to the first law of thermodynamics:
$\Delta Q = \Delta U + W$

For isothermal: $\Delta U = 0 \rightarrow \Delta Q = W$
For adiabatic: $\Delta Q = 0 \rightarrow \Delta U = -W$
Thus, both conditions cannot hold true at once.

Q.13 Does entropy increase in Carnot engine for each cycle?

Answer: No, the entropy remains the same after a complete cycle.
Reason: Carnot cycle is a reversible process.
Net change in entropy (ΔS) = 0.

Q.14 Why is efficiency defined as W/Q?

Answer:
Efficiency (η) = Work output (W) / Heat input (Q)

W = useful work done

Q = energy absorbed from hot reservoir
This ratio tells how effectively input energy is converted into useful output.

Q.15 Does entropy increase due to friction?

Answer: Yes.
Reason: Friction converts mechanical energy into heat, increasing disorder and hence entropy.
$\Delta S = \Delta Q / T \rightarrow$ as heat increases, entropy increases.

Q.16 Similarities & Differences: Refrigerator vs Air Conditioner

Similarities:

- Both are cooling devices
- Work using refrigeration cycle
- Transfer heat from low to high temperature reservoir

Differences:

Feature	Refrigerator
Purpose	Preserve Food
Circulation	Inside unit
Components	Two separate units
Heat Absorption	Inside coils
Usage	Inside house/kitchen

Q.17 What is meant by reverse entropy? Significance of entropy?

Answer
Reverse Entropy:
Increase in order or structure in a region (local decrease in entropy)

Significance of Entropy:

- Indicates direction of heat flow
- Describes disorder/randomness
- Helps in defining energy efficiency
- Entropy is a state function like temperature and pressure

Q.18 Difference: Heat Transfer vs Thermodynamics

Aspect	Heat Transfer
Definition	Study of rate and modes

	of heat flow
Time factors	Consider time
Units	Watt (W)
Focus	Conduction,convection,radiation
Type	Non-equilibrium

Q.19 Shaking coffee in thermos (Adiabatic Process)

(i) Work done? Yes
(ii) Internal energy increases? Yes
(iii) Temperature increases? Slightly, due to friction
(iv) Heat from outside? No, thermos is insulated

Q.20 System changes from P_1V_1 to P_2V_2 (Isothermal)

Answer: constant → $\Delta T = 0$
Hence, $\Delta U = 0$
Internal energy remains constant

Q.21 Conditions for Thermodynamic Equilibrium

Answer:
Thermal Equilibrium: Uniform temperature
Mechanical Equilibrium: No net force or pressure difference
Chemical Equilibrium: No change in chemical composition

Q.22 Can internal energy increase while temperature remains constant?

Answer: Yes
Example: Melting of ice

- Temperature stays constant
- Potential energy increases, raising internal energy

Q.23 Why does tire pressure increase while driving?

Answer:

- Work against road friction → Heat
- Heat absorbed by gas molecules → Increased kinetic energy
- More collisions → Higher pressure

Q.24 Prove area under P-V graph = Work Done

Answer

For isobaric process:
Work = P × ΔV
On P-V graph:
Area under the curve = P × ΔV = Work done
Units: Nm = Joules

Q.25 Why are all processes in a refrigerator isothermal?
Answer:

- Temperature inside is kept constant via thermostat
- Heat is removed continuously at constant temperature
- Refrigeration cycle is approximately isothermal at each stage

Additional Questions

1. Why is food cooked quicker in a pressure cooker?
Answer:
In a pressure cooker, due to increased pressure, the boiling point of water rises.

At atmospheric pressure, the boiling point of water is about 100°C at sea level.

In a pressure cooker, water boils at 121°C (250°F).

This higher temperature allows food to cook much faster.

Also, the food doesn't dry out because water stays in liquid form.

Cooking reactions are faster at higher temperatures, hence quicker cooking.

2. Give an example of a process in which no heat is transferred to or from the system but the temperature of the system changes.
Answer
Adiabatic Process:
In an adiabatic process, no heat enters or leaves the system, but the temperature changes.

Adiabatic Expansion: Temperature falls.
Adiabatic Compression: Temperature rises.

Examples:

- Rapid escape of air from a burst tyre.
- Expansion and compression of air due to sound waves.
- Cloud formation in the atmosphere.

3. Why is the efficiency of a Carnot engine less than 100%?

(FBISE-2014, 2015 ON, 2018 SUPP)

Answer:

Carnot engines cannot convert all heat into mechanical energy.

Some heat is always rejected to the sink and lost due to friction.

100% efficiency means all heat converts to useful work — which is not practically possible.

Efficiency Formula:

Efficiency (η) = $(1 - T_2/T_1) \times 100$

100% efficiency is only possible if $T_2 = 0$ K or $T_1 = \infty$.

Both are not achievable, hence Carnot engine efficiency can never be 100%.

4. Is it possible to convert internal energy into mechanical energy? Explain with an example.

(FBISE-2022 ON)

Answer:

Yes, internal energy can be converted into mechanical energy.

Example:

In adiabatic expansion, gas does work on the surroundings using its internal energy, which decreases as a result.

This principle is also used in gas liquefaction processes.

5. Is it possible to cool a room by keeping the refrigerator door open?

Answer:

No, the temperature of the room will not decrease — in fact, it might increase slightly.

Reason:

- A refrigerator absorbs heat from inside but rejects it outside at the same rate.
- Additionally, the motor produces heat due to friction.

Net result: the room warms slightly.

6. Why can mechanical energy be completely converted into heat energy, but not vice versa?

Answer:

Mechanical energy can be absorbed entirely by molecules as kinetic energy and converted into heat.

But heat energy cannot be completely converted into mechanical energy because some of it is retained as internal energy by the system.

7. Carnot Engine Efficiency Problem:

Given:

$T_2 = 7°C = 273 + 7 = 280$ K

Efficiency $\eta_1 = 50\%$

Desired efficiency $\eta_2 = 70\%$

Step 1: Calculate T_1 for 50% efficiency:

$\eta_1 = 1 - T_2/T_1$

$0.5 = 1 - 280/T_1$

$280/T_1 = 0.5$

$T_1 = 560$ K

Step 2: Calculate T_1' for 70% efficiency:

$\eta_2 = 1 - 280/T_1'$

$0.7 = 1 - 280/T_1'$

$280/T_1' = 0.3$

$T_1' = 933.3$ K

Step 3: Increase in temperature:

$T_1' - T_1 = 933.3$ K $- 560$ K $= 373.3$ K