MCQs
THERMODYNAMICS
Physics Without Fear

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Zeroth law of thermodynamics: Two systems A and B each in thermal equilibrium with a third system C are in thermal equilibrium with each other. The thermodynamic equilibrium implies that the systems are at same temperature.

The temperature of a system is a bulk property. It can be assigned to an assembly of a large number of particles but not to an individual particle. Temperature indicates the direction of net transfer of heat between two bodies.
The temperature is measured on a scale which is based on some thermodynamic property. If thermodynamic property (e.g., electrical resistance) varies \textbf{linearly} with temperature then the temperature of the body whose resistance is is given by

\[
\frac{t_R}{100} = \frac{R_t - R_0}{R_{100} - R_0}
\]

\[T \text{ (Absolute)} = t \text{ (celsius)} + 273.15.\]
Thermodynamics: At a glance

**Heat:** It is energy in transit. It is roughly the sum of kinetic energies of random motion of particles constituting the system. It is not a state variable like temperature, volume, pressure or internal energy. **Internal energy depends only on the actual state of a system and not on how that state is attained.** Therefore, change in internal energy is independent of the path taken by the system for the change.

The equation of state for an ideal gas:
For \( n \) moles \( PV = nRT \) where \( R = 8.31 \text{ J/mol K} \).
First law of thermodynamics:
If a quantity of heat $dQ$ is given to a system, it changes its internal energy by amount $dU$ and does work $dW$; we have

$$dQ = dU + dW$$

The first law of thermodynamics is just a manifestation of the principle of conservation of energy.
If the system is a gas and the work is done under constant pressure $P$ resulting in a changes $dV$ in the volume of the gas, then $dW = PdV$ and the first law reads

$$dQ = dU + PdV$$
**Indicator diagram**: A graph between $P$ and $V$ of a system is called an indicator diagram. The figure shows the graph when pressure remains constant and the volume changes from $V_1$ to $V_2$. The work done on the system is the area under the $PV$ curve.
Thermodynamics: At a glance

If $P$ is not constant, the work done is given by

$$ W = \int_{V_1}^{V_2} P \, dV. $$

The work done is area under the indicator (P-V) graph.
Remember: An adiabatic P-V graph is steeper than an isotherm.

Work done in an isothermal process:

$$W = \mu RT \ln(V_2/V_1)$$

Work done in an adiabatic process:

$$W = \frac{\mu R(T_1 - T_2)}{(\gamma - 1)}$$
If the change in the internal energy is zero, the first law gives

\[ dQ = PdV. \]

This means that whatever heat energy is supplied to the system, it is spent in doing work by the system. If heat is extracted from the system, then work must be done on the system.
Efficiency of an ideal engine (Carnot Engine) is given by,

\[ \eta = 1 - \frac{Work \ output}{Heat \ input} = 1 - \frac{Q_2}{Q_1} = 1 - \frac{T_2}{T_1} \]
1. A Carnot engine whose sink is at 300 K has an efficiency of 40%. By how much should the temperature of the source be increased so as to increase its efficiency by 50% of original efficiency?

1) 380 K
2) 275 K
3) 325 K
4) 250 K
2. If Q, E and W denote respectively the heat added, change in internal energy and the work done in a closed cycle process, then:
1) Q = 0
2) W = 0
3) Q = W = 0
4) E = 0
Q3. In thermodynamic processes which of the following statements is not true?

1) In an adiabatic process $PV^\gamma = \text{constant}$
2) In an adiabatic process the system is insulated from the surroundings
3) In an isochoric process pressure remains constant
4) In an isothermal process the temperature remains constant.
Q4. The internal energy change in a system that has absorbed 2 Kcal of heat and done 500 J of work is:

1) 7900 J
2) 8900 J
3) 6400 J
4) 5400 J
Q5. If $\Delta U$ and $\Delta V$ represent the increase in internal energy and work done by the system respectively in a thermodynamic process, which of the following is true?

1) $\Delta U = -\Delta W$, in an isothermal process
2) $\Delta U = -\Delta W$, in an adiabatic process
3) $\Delta U = \Delta W$, in an isothermal process
4) $\Delta U = \Delta W$, in an adiabatic process
Q6. During an isothermal expansion, a confined gas does $-150 \text{ J}$ of work against its surroundings. This implies that

1) 150 J of heat has been added to the gas
2) 150 J of heat has been removed from the gas
3) 300 J has been added to the gas
4) no heat is transferred because the process is isothermal
Q7. A thermodynamic system is taken through the cycle ABCD as shown in figure. Heat rejected by the gas during the cycle is:

1) PV
2) 2PV
3) 4PV
4) 1/2 PV
Q8. A gas is taken through the cycle A B C A, as shown. What is the net work done by the gas?

1) Zero
2) \(-2000\) J
3) 2000 J
4) 1000 J
Q9. Pick the only reversible process among the following processes:

1) Movement of a particle on a frictionless track
2) Passage of current through a resistor
3) Passage of heat from water at 40 °C to water at 20 °C
4) Expansion of a gas coming out of a nozzle
Q10. Pick the one that is not a state variable of a thermodynamic system:

1) Temperature
2) Heat
3) Volume
4) Internal energy
Q11. The second law of thermodynamics is concerned essentially with

1) nature of heat flow
2) amount of heat flow
3) direction of heat flow
4) speed of heat flow
Q12. Consider the following two statements:
   A: A system is in steady state if its properties are independent of space.
   B: A system is in steady state if its properties are independent of time.
   Which of the following statements is true?
   1) Both A and B are true
   2) A is false but B is true
   3) A is true but B is false
   4) Both A and B are false
Q13. Consider a refrigerator in a kitchen. Take the refrigerator and everything in it to be our system. Which best describes the system's surroundings?

1) All of the air in the kitchen
2) Pans and gas stove in the kitchen
3) The air inside the refrigerator
4) Everything in the universe external to the system
Q14: Two moles of a gas undergo expansion from volume V to 10V at a temperature of 27°C. The work done in the process in J is

1) $4.5 \times 10^2$
2) $1.0 \times 10^3$
3) $5.0 \times 10^3$
4) $1.1 \times 10^4$
Q15: Two moles of a monatomic gas are taken adiabatically from a state where its temperature is 27 °C to a state where its temperature is 127 °C. The work done in the process in J is
1) $2.5 \times 10^3$
2) $4.2 \times 10^3$
3) $6.8 \times 10^5$
4) $1.1 \times 10^6$
Q16: A system goes to state 1 one from state 2. It can take paths labelled A, B, C. The change in internal energy of the system is
1) smallest on A
2) smallest on B
3) smallest on C
4) same on all paths.
Q17: An ideal gas heat engine operates between 227 °C and 127 °C. It absorbs $6.0 \times 10^4$ cal of heat at higher temperature. Amount of heat converted into work is:

1) $4.8 \times 10^4$ cal
2) $6.0 \times 10^4$ cal
3) $2.4 \times 10^4$ cal
4) $1.2 \times 10^4$ cal
Q18. An engine has efficiency of 1/6. When the temperature of sink is reduced by 62 °C, its efficiency is doubled. Temperature of the source is:
1) 99 °C
2) 124 °C
3) 37 °C
4) 62 °C
Q19: Which of the following processes is reversible?

1) Transfer of heat by conduction
2) Transfer of heat by radiation
3) Isothermal compression
4) Electrical heating of a nichrome wire
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Thanks

For feedback

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