Thermodynamics JEE Main PYQ - 3

Total Time: 25 Minute **Total Marks:** 40

Instructions

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1. Test will auto submit when the Time is up.
2. The Test comprises of multiple choice questions (MCQ) with one or more correct answers.
3. The clock in the top right corner will display the remaining time available for you to complete the examination.

Navigating & Answering a Question

1. The answer will be saved automatically upon clicking on an option amongst the given choices of answer.
2. To deselect your chosen answer, click on the clear response button.
3. The marking scheme will be displayed for each question on the top right corner of the test window.

Thermodynamics

1. An ideal gas at atmospheric pressure is adiabatically compressed so that its density becomes 32 times of its initial value. If the final pressure of gas is 128 atmospheres, the value of ?γ?of the gas is : **(+4, -1)**
[Online April 22, 2013]

a. 1.5

b. 1.4

c. 1.3

d. 1.6

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2. An ideal monoatomic gas is confined in a cylinder by a spring loaded piston of cros section $8.0 \times 10^{-3}\,m^2$. Initially the gas is at 300K and occupies a volume of $2.4 \times 10^{-3}\,m^3$ and the spring is in its relaxed state as shown in figure. The gas is heated by a small heater until the piston moves out slowly by $0.1\,m$. The force constant of the spring is $8000\,N/m$ and the atmospheric pressure is $1.0 \times 10^5\,N/m^2$. The cylinder and the piston are thermally insulated. The piston and the spring are massless and there is no friction between the piston and the cylinder. The final temperature of the gas will be : (Neglect the heat loss through the lead wires of the heater. The heat capacity of the heater coil is also negligible) **(+4, -1)**
[5 Sep. 2020 (I)]

a. 300 K

b. 800 K

c. 500 K

d. 1000 K

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3. For the given cyclic process CAB as shown for a gas, the work done is : **(+4, -1)**
[12•Jan.•2019•I]

a. 1 J

b. 5 J

c. 10 J

d. 30 J

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4. Half mole of an ideal monoatomic gas is heated at constant pressure of 1 atm from $20^{\circ}C$ to $90^{\circ}C$. Work done by gas is close to : (Gas constant R = $8.31\,J\,/mol-K$) **(+4, -1)**

[10 Jan. 2019 II]

a. 73 J

b. 291 J

c. 581 J

d. 146 J

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5. Ratio of molar heat capacity at constant pressure and at constant volume for monoatomic and diatomic gas is? **(+4, -1)**

[10 Jan. 2019 I]

a. 25 : 21

b. 21 : 25

c. 16 : 25

d. 25 : 16

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6. A gas is kept in a vessel of volume 0.2 m^3 at temperature 300 K and pressure 1 bar. The molar heat capacity of gas at constant volume is 5 cal/mol K. The heat (kcal) required to raise the temperature to 400 K is ______. **(+4, -1)**

[27-Jan-2024-Shift-2]

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7. Given below are two statements : one is labelled as Assertion A and the other is labelled as Reason R **(+4, -1)**

Assertion A: Efficiency of a reversible heat engine will be highest at $-273^{\circ}C$ temperature of cold reservoir

Reason R: The efficiency of Carnot's engine depends not only on temperature of cold reservoir but it depends on the temperature of hot reservoir too and is given as $n=\left(1-\frac{T_2}{T_1}\right)$

In the light of the above statements, choose the correct answer from the options given below [29-Jan-2023•Shift•1]

a. A is true but R is false

b. Both A and R are true and R is the correct explanation of A

c. Both A and R are true but R is NOT the correct explanation of A

d. A is false but R is true

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8. $1\,g$ of a liquid is converted to vapour at $3 \times 10^5 Pa$ pressure If 10% of the heat supplied is used for increasing the volume by $1600\,cm^3$ during this phase change, then the increase in internal energy in the process will be: **(+4, -1)**

[24-Jan-2023 Shift 1]

a. $4800\,J$

b. $4320\,J$

c. $4.32 \times 10^8\,J$

d. $432000\,J$

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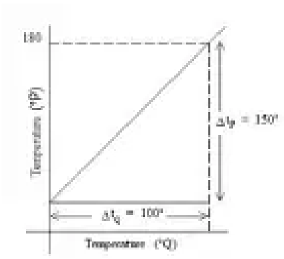
9. The graph between two temperature scales P and Q is shown in the figure Between upper fixed point and lower fixed point there are 150 equal divisions of scale P and 100 divisions on scale Q : The relationship for conversion between the two scales is given by:- **(+4, -1)**

[25-Jan-2023 Shift 2]



a. $\frac{t_P}{100} = \frac{t_Q - 180}{150}$

b. $\frac{t_Q}{150} = \frac{t_P - 180}{100}$

c. $\frac{t_p}{180} - \frac{t_Q - 40}{100}$

d. $\frac{t_Q}{100} = \frac{t_P - 30}{150}$

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10. Let η_1 is the efficiency of an engine at $T_1 = 447°C$ and $T_2 = 147°C$ while η_2 is the efficiency at $T_1 = 947°C$ and $T_2 = 47°C$ The ratio $\frac{\eta_1}{\eta_2}$ will be : **(+4, -1)**

[25-Jul-2022-Shift-2]

a. 0.41

b. 0.56

c. 0.73

d. 0.70

Answers

1. **Answer: b**

Explanation:

Volume of the gas
$v = \frac{m}{d}$ and
using $pV^{\gamma} =$ constant
$\frac{P'}{P} = \frac{V}{V'} = \left(\frac{d'}{d}\right)^{\gamma}$
or $128 = (32)^{\gamma}$
$\therefore \gamma = \frac{7}{5} = 1.4$

Concepts:

1. Thermodynamics:

Thermodynamics in physics is a branch that deals with heat, work and temperature, and their relation to energy, radiation and physical properties of matter.

Important Terms

System

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Laws of Thermodynamics

Zeroth Law of Thermodynamics

The Zeroth law of thermodynamics states that if two bodies are individually in equilibrium with a separate third body, then the first two bodies are also in thermal equilibrium with each other.

First Law of Thermodynamics

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Third Law of Thermodynamics

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2. **Answer: b**

Explanation:

$$A = 8 \times 10^{-3}\, m^2$$
$$T_1 = 300\, K$$
$$V_1 = 2.4 \times 10^{-3}\, m^3$$
$$V_2 = V_1 + A\Delta X$$
$$= 2.4 \times 10^{-3} \times 8 \times 10^{-3} \times 0.1$$
$$= 3.2 \times 10^{-3}\, m^3$$
$$K = 8000\, N/m$$
$$T_2 = ?$$
$$P_1 = 10^5 N/m^2$$
$$P_2 = P_0 + \frac{kx}{A} = 10^5 + \frac{8000 \times 0.1}{8 \times 10^{-3}}$$
$$= 2 \times 10^5\, N/m^2$$
$$\frac{P_1 V_1}{T_1} = \frac{P_2 V_2}{T_2}$$
$$\frac{10^5 \times 2.4 \times 10^{-3}}{300} = \frac{2 \times 10^5 \times 3.2 \times 10^{-3}}{T_2}$$
$$T_2 = \frac{3.2 \times 300}{1.2}$$
$$= 800\, K$$

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3. **Answer: c**

Explanation:

Since P-V indicator diagram is given, so work done by gas is area under the cyclic diagram.
$\therefore \Delta W =$ Work done by gas $= \frac{1}{2} \times 4 \times 5J$
$= 10\,J$

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4. **Answer: b**

Explanation:

$$WD = P\Delta V = nR\Delta T = \frac{1}{2} \times 8.31 \times 70$$

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5. **Answer: a**

Explanation:

The correct answer is(A): 25 : 21

$\frac{5}{3} / \frac{7}{5} \Rightarrow \frac{5}{3} x \frac{7}{5} = \frac{25}{21}$

Concepts:

1. Specific Heat Capacity:

Specific heat of a solid or liquid is the amount of heat that raises the temperature of a unit mass of the solid through 1°C.

Molar Specific Heat:

The Molar specific heat of a solid or liquid of a material is the heat that you provide to raise the temperature of one mole of solid or liquid through 1K or 1°C.

Specific Heat at Constant Pressure or Volume:

The volume of solid remains constant when heated through a small range of temperature. This is known as specific heat at a constant volume. It is denoted as C_V.

The pressure of solid remains constant when heated through a small range of temperature. This is known as specific heat at constant pressure which can be denoted as C_P.

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6. **Answer: 4 - 4**

Explanation:

Explanation:
Given:Molar specific heat at constant volume, = 5 / The initial temperature of the gas, $_1$ = 300 The final temperature of the gas, $_2$ = 400 Volume of the gas, = 0.2 ^{3} Pressure of the gas, = 1 bar = 10^5 / ^{2} Change in temperature, Δ = $_2$ − $_1$ = 400 − 300 = 100 Using the ideal gas equation, = = —Where is the number of moles of the gas.Thus, the number of moles of gas at 1 atm is $= \frac{(10)^5 \times (0.2)}{8.31 \times 300}$ ≈ 8 The molar heat capacity of hydrogen at constant volume is (Δ) = Δ (Δ) = 8 × 5 × 100 (Δ) = 4 Thus, the heat required to raise the temperature to 400 is 4 kcal. Hence, the correct answer is 4.

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7. **Answer: b**

Explanation:

Assertion A is true, stating that the efficiency of a reversible heat engine will be highest at -273°C (0 Kelvin), which is the temperature of the cold reservoir.
Reason R is also true, explaining the efficiency of Carnot's engine using the formula: η = 1 - $\frac{T_2}{T_1}$, where Tc is the temperature of the cold reservoir and Th is the temperature of the hot reservoir.
However, Reason R doesn't directly explain why the efficiency is highest at -273°C, which is stated in Assertion A. The formula in Reason R does show how the efficiency is affected by the temperatures of both the hot and cold reservoirs, but it doesn't directly correlate with the statement in Assertion A about the temperature of -273°C being the point of highest efficiency.
So, the correct option is (B): Both A and R are true and R is the correct explanation of A

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8. **Answer: b**

Explanation:

Work done $= P\Delta V$
$= 3 \times 10^5 \times 1600 \times 10^{-6}$
$= 480J$
Only 10% of heat is used in work done.
Hence $\Delta Q = 4800J$
The rest goes in internal energy, which is 90% of heat.
Change in internal energy $= 0.9 \times 4800 = 4320J$
The correct answer is (B) : 4320 J

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9. **Answer: d**

Explanation:

The correct answer is (D) : $\frac{t_Q}{100} = \frac{t_P-30}{150}$

$$\frac{\text{reading on scale} - \text{Lower fixed point}}{\text{upper fixed po int-lower fixed point}} = \text{constant}$$

$$\frac{t_p-30}{180-30} = \frac{t_Q-0}{100-0}$$

$$\frac{t_p-30}{150} = \frac{t_Q}{100}$$

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10. **Answer: b**

Explanation:

Efficiency $\eta = 1 - \frac{T_L}{T_H}$

$\eta_1 = 1 - \frac{147+273}{447+273} = 1 - \frac{420}{720}$

$\eta_1 = \frac{300}{720}$

$\eta_2 = 1 - \frac{47+273}{947+273} = 1 - \frac{320}{1220}$

$\eta_2 = \frac{900}{1220}$

$\frac{\eta_1}{\eta_2} = \frac{300}{720} \times \frac{1220}{900} = \frac{122}{72\times3}$

$\frac{\eta_1}{\eta_2} = 0.56$

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