Thermodynamics SCAN 1st **MCQ March 15th 2024**

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⟵ Please enter you student number, and write your name above.

NAME, First Name :

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Duration : 30 minutes - Only lecture and tutorial booklet allowed and all calculators authorised - No wifi no 4/5G

Q1 During its free fall from an initial ($h_{ini} = 100\,\text{km}$) to a final height ($h_{fin} = 47\,100\,\text{m}$), a meteor of mass $m = 80.0\,\text{kg}$ (isolated system) reaches the final terminal velocity $v_{fin} = 199\,\text{km/h}$. Assuming the meteor has a nil initial velocity, demonstrate the literal expression of its internal energy variation during the free fall.
Reminder : $g = 9.81\,\text{m/s}^2$.

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A meteor, considered as an isolated system, $\Delta E_{tot} = \Delta E_k^{macro} + \Delta E_p^{macro} + \Delta U = 0$. So, knowing that $\Delta E_k^{macro} = \frac{1}{2}m[(v_{fin})^2 - (v_{ini})^2]$ and $\Delta E_p^{macro} = mg(h_{fin} - h_{ini})$ we obtain : $\Delta U = -\frac{1}{2}m[(v_{fin})^2 - (v_{ini})^2] - mg(h_{fin} - h_{ini})$. (4 pts)

Q2 Give the numerical value of internal energy variation ΔU in MJ.

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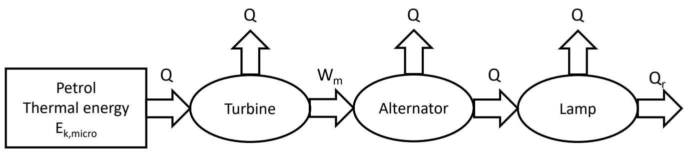
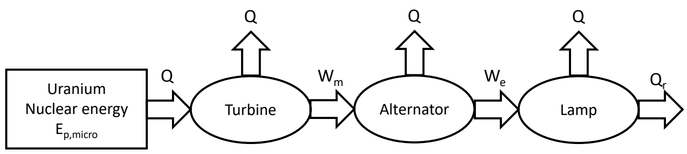
Q3 A system contains only liquid water at $T = 150\,°\text{C}$ and $P = 10\,\text{bar}$. How could you entirely vaporize the water knowing that the vapour pressure $P_w^*(423\,\text{K}) = 4.8\,\text{bar}$ and you can modify only the system's pressure ?

☐ Decrease P down to 4.8 bar ☐ Increase P ■ Decrease P down to 4 bar

Q4 Which energy chain showing the light generation Q_r from a lamp in a room is correct ?

☐ 

■ 

Q5 A wind turbine of 1 MW has an efficiency of 30%. Calculate the energy harnessed by the turbine from the wind during one day knowing that the turbine usually works only 67% of the entire day. Give the result in MWh. Reminder : 1 Wh = 3600 J.

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Q6 What type of energy is the gasoline ?

■ Microscopic potential energy ☐ Macroscopic potential energy ■ Final energy ☐ Useful energy

Q7 In a room (close system of volume $V = 40\,\mathrm{m}^3$) there is humid air at $T = 30\,°\mathrm{C}$, $P = 1.0\,\mathrm{atm}$ and $RH_{ini} = 44\%$. A mass $m_w = 0.50\,\mathrm{kg}$ of liquid water is spilled in the room. After some time, the system will be at equilibrium at the same T, P and V. Demonstrate the literal expression of the equilibrium value of relative humidity RH_{eq} knowing the vapour pressure $P^*_w(30\,°\mathrm{C}) = 0.042\,\mathrm{atm}$. Reminder : $M_w = 18\,\mathrm{g/mol}$, $R = 8.314\,\mathrm{J/(mol\,K)}$, 1 atm = 101 325 Pa, 0 °C = 273 K.

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First we evaluate the maximum liquid water that can evaporate in the air : $m^{evap}_{w,max} = \frac{(1-RH_{ini}/100)P^*_w(T)VM_w}{RT}$. Then, being $m^{evap}_{w,max} > m_w$, we can say that all the liquid water will evaporate leading to : $RH_{eq} = RH_{ini} + \frac{m_w RT}{M_w V P^*_w(T)} \times 100$ (4 pts)

Q8 Give the numerical value of RH_{eq} in %.

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Q9 A volume ($V_1 = 1.0\,\mathrm{m}^3$) of dry air (closed system) on the earth surface ($h_1 = 0\,\mathrm{m}$) is at $T_1 = 15\,°\mathrm{C}$ and $P_1 = 1.0\,\mathrm{atm}$. It is then transported to a height $h_2 = 10\,\mathrm{km}$ at $T_2 = -44\,°\mathrm{C}$ and $P_2 = 0.206\,\mathrm{atm}$. Demonstrate the literal expression of air density ρ_{air} at h_2. Reminder : $g = 9.81\,\mathrm{m/s}^2$, $M_{air} = 28.8\,\mathrm{g/mol}$, $R = 8.314\,\mathrm{J/(mol\,K)}$, 1 atm = 101 325 Pa, 0 °C = 273 K.

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Being a close system, the moles of air are constant and : $\frac{PV}{T} = const$.
So, $V_2 = \frac{P_1}{P_2}\frac{T_2}{T_1}V_1$ and $n_{air} = \frac{P_1V_1}{RT_1}$.
Then, air density at h_2 is : $\rho_{air} = \frac{m_{air}}{V_2} = \frac{n_{air}M_{air}}{V_2}$ leading to : $\rho_{air} = \frac{P_2M_{air}}{RT_2}$. (4 pts)

Q10 Give the numerical value of ρ_{air} in $\mathrm{kg/m}^3$.

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