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GATE

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AIR 403	EC	MOHAN KUMAR SINGH
AIR 567	EE	SHANKAR JHA
AIR 571	ME	VIJENDER MEENA

FREE APP CLASS SCHEDULE

MECHANICAL ENGINEERING

HMT	MONDAY Live @11AM	YOGESH SIR
PRODUCTION	TUESDAY Live @11AM	GAURAV SIR
SOM	WEDNESDAY Live @8PM	MUKESH SIR
THERMODYNAMICS	THURSDAY Live @11AM	KANISTH SIR ⇒ 3 HRS
ENGINEERING MATHEMATICS	FRIDAY Live @11AM	ANANT SIR

ISRO | BHEL | DRDO & OTHER PSUs

Thermodynamics

Second Law

MOST EXPECTED QUESTIONS

PART-3

Live@ 3pm

Kanisth sir

Q. The unit of entropy is

(a) kg/JK

(b) J/kg.m

(c) J/kg K ✓

(d) J / S

① → ⓒ

$$\boxed{\Delta S = \int_1^2 \frac{\delta Q_R}{T}}$$

$$\frac{J}{K} \text{ (OR) } \frac{KJ}{K}$$

$$= \frac{J}{kg\,K} \text{ (OR) } \frac{KJ}{kg.K}$$

Statement (I): There is entropy transfer both in heat transfer and work transfer. ✗

→ HIGH GRADE ENERGY

Statement (II): Both heat and work are energy in transition. ✓

[ESE : 2013]

②

STATEMENT (I) IS WRONG

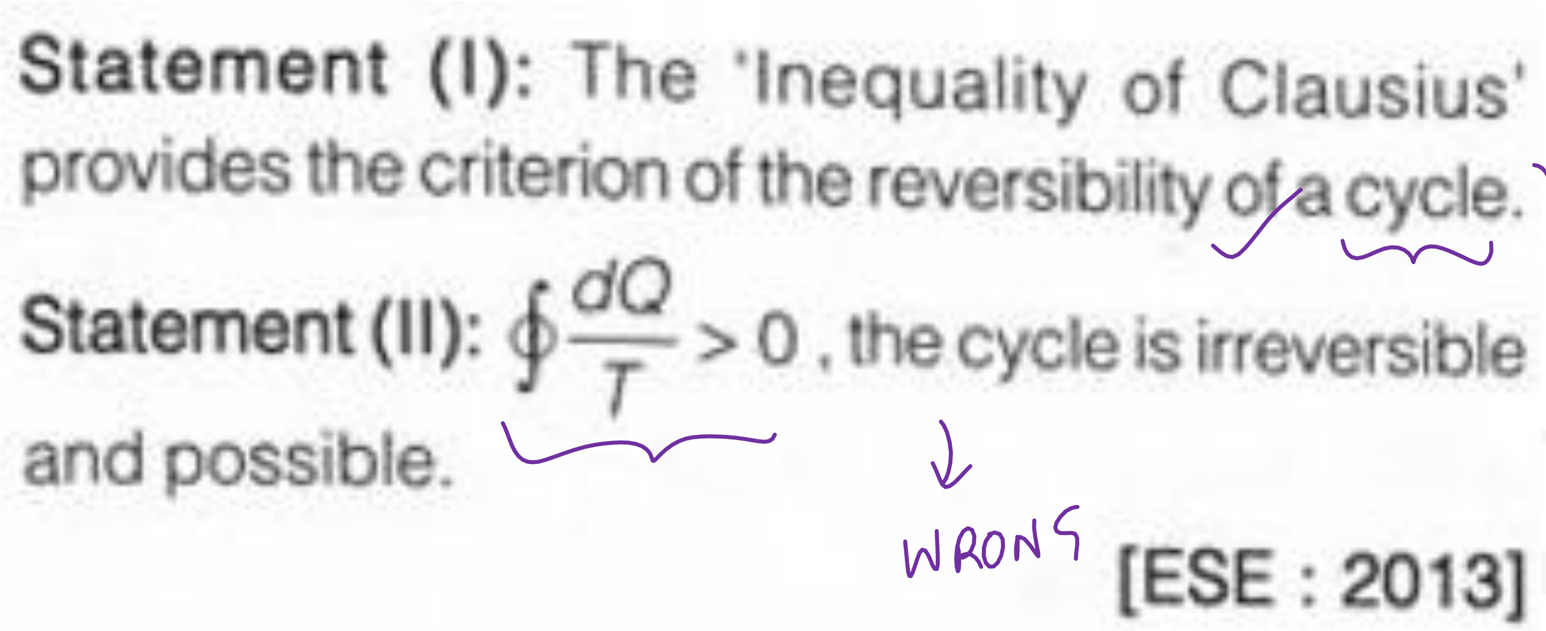
Ⓐ

Ⓑ

Ⓒ

Ⓓ

③


Statement (I): The 'Inequality of Clausius' provides the criterion of the reversibility of a cycle. ✓

Statement (II): $\oint \frac{dQ}{T} > 0$, the cycle is irreversible and possible.

WRONG

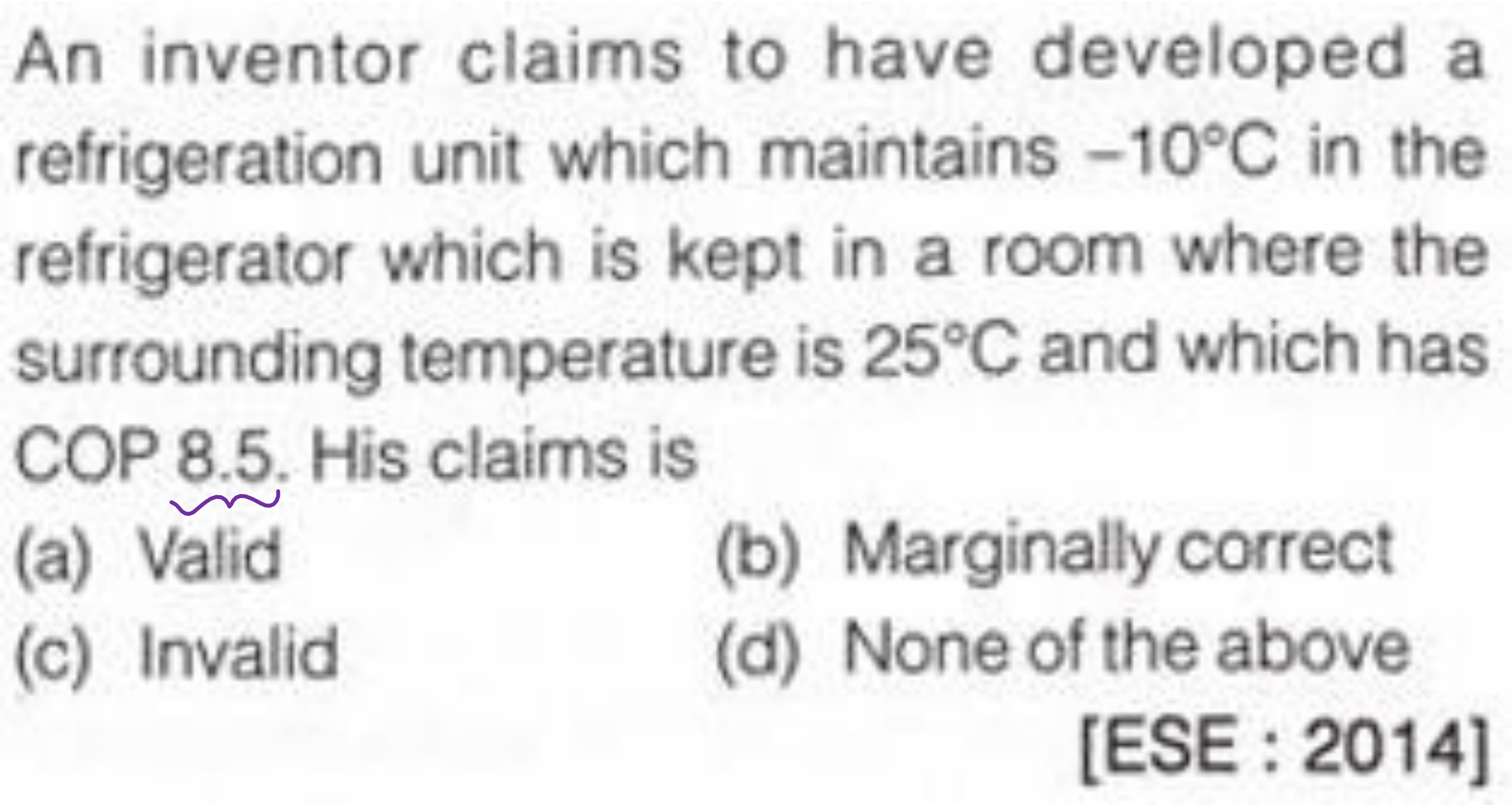
[ESE : 2013]

$$\boxed{\oint \frac{\delta Q}{T} \le 0}$$

$\oint \frac{\delta Q}{T} < 0$ IRRE & POSSIBLE

$\oint \frac{\delta Q}{T} = 0$ REV & POSSI

$\oint \frac{\delta Q}{T} > 0$ IMPOSSIBLE



An inventor claims to have developed a refrigeration unit which maintains –10°C in the refrigerator which is kept in a room where the surrounding temperature is 25°C and which has COP 8.5. His claims is

(a) Valid (b) Marginally correct

(c) Invalid (d) None of the above

[ESE : 2014]

④

$$COP_{REF} = \frac{-10+273}{25-(-10)}$$

$$= \boxed{\frac{263}{35}}$$

$\Rightarrow$

⑤ → ⓑ

Two identical finite bodies of constant heat capacity at temperatures T_1 and T_2 are available to do work in a heat engine. The final temperature T_f reached by the bodies on delivery of maximum work is

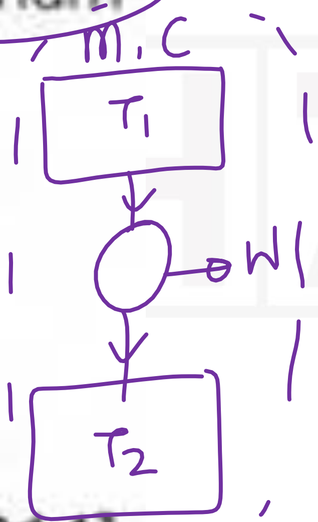
(a) $T_f = \dfrac{T_1 + T_2}{2}$

[✓ (b) $T_f = \sqrt{T_1 T_2}$]

(c) $T_f = T_1 - T_2$

(d) $T_f = \sqrt{T_1^2 + T_2^2}$

[ESE : 2014]



mc

ESE
CSE
PSUs
STATE AE

} PYQs

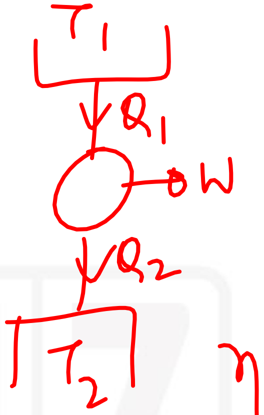
** $\boxed{T_f = \sqrt{T_1 T_2}}$

$\boxed{W_{MAX} = mc\left(\sqrt{T_1} - \sqrt{T_2}\right)^2}$

⑥

Any thermodynamic cycle operating between two temperature limits is reversible if the product of the efficiency when operating as a heat engine and the COP when operating as a refrigerator is equal to 1. (TRUE/FALSE) **[1 Mark]**

FALSE



$$\eta = 1 - \frac{T_2}{T_1} = \frac{T_1 - T_2}{T_1}$$

$$COP_{RE} = \frac{T_2}{T_1 - T_2}$$

$$\frac{T_2}{\cancel{T_1 - T_2}} \times \frac{\cancel{(T_1 - T_2)}}{T_1}$$

$$= \frac{T_2}{T_1}$$

For two cycles coupled in series, the topping cycle has an efficiency of 30% and the bottoming cycle has an efficiency of 20 %. The overall combined cycle efficiency is **[2 Marks]**

(A) 50%
[✓ (B) 44%]
(C) 38%
(D) 55%

⑦ → ⓑ

$$\boxed{\begin{array}{l}(1-\underline{\underline{\eta_0}}) = (1-\eta_1)(1-\eta_2) \\ \qquad - - - - (1-\eta_n)\end{array}}$$

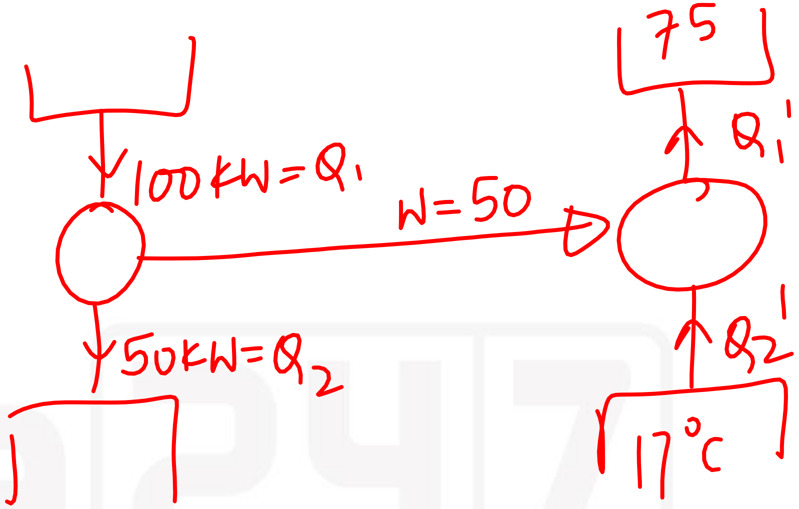
⑧ → Ⓑ

An irreversible heat engine extracts heat from a high temperature source at a rate of 100 kW and rejects heat to a sink at a rate of 50 kW. The entire work output of the heat engine is used to drive a reversible heat pump operating between a set of independent isothermal heat reservoirs at 17 ^{0}C and 75 ^{0}C. The rate (in kW) at which the heat pump delivers heat to its high temperature sink is

[2 Marks]

(A) 50 [✓ (B) 250]

(C) 300 (D) 360

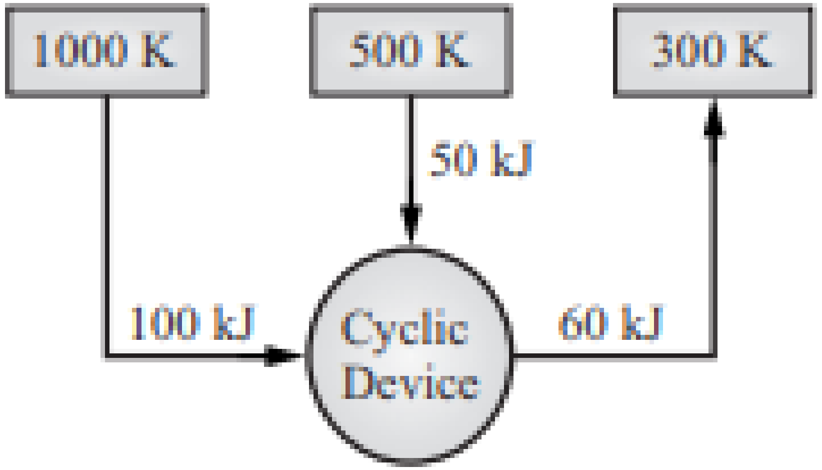


$$COP_{HP} = \frac{Q_1'}{W} = \frac{T_1}{T_1 - T_2}$$

$$Q_1' = \frac{50 \times (75+273)}{(75-17)}$$

$\Rightarrow$

Q. A cyclic device operates between three thermal reservoirs, as shown in the figure. Heat is transferred to/from the cycle device. It is assumed that heat transfer between each thermal reservoir and the cyclic device takes place across negligible temperature difference. Interactions between the cyclic device and the respective thermal reservoirs that are shown in the figure are all in the form of heat transfer. [2 Marks]



For two cycles coupled in series, the topping cycle has an efficiency of 30% and the bottoming cycle has an efficiency of 20 %. The overall combined cycle efficiency is **[2 Marks]**

(A) 50%	(B) 44%
(C) 38%	(D) 55%

Q. A heat engine developes 60 kW work having an efficiency of 60%, Amount of heat rejected will be: -

(a) 400 kW

(b) 10 kW

(c) 40 kW ✓

(d) 20 kW

⑨ — Ⓒ

$$\eta = \frac{W_{o/p}}{Q_s}$$

$$0.6 = \frac{60}{Q_s}$$

$$Q_s = \frac{\cancel{60}0}{0.\cancel{6}} = 100$$

$$Q_s = W + Q_R$$

$$Q_R = 100 - 60$$

$$= \underline{\underline{40\,kW}}$$

Q. In Carnot cycle, addition and rejection of heat takes place at: -

⑩

(a) Constant pressure

(b) Constant temperature ✓

(c) Constant volume

(d) Constant speed

Q. The change of entropy, when heat is absorbed by the gas, is

(a) positive ✓

(b) negative

(c) positive or negative

(d) zero

11

$\frac{\delta Q_R}{T}$

$S_{gen} \to 0, +ve$

$$\Delta S = \left(\frac{\delta Q}{T}\right)_{rev} + S_{gen}$$

Q. Which one of the following statements applicable to a perfect gas will also be true for an irreversible process?

(a) $\delta Q = dU + \boxed{pdV}$

(b) $dQ = TdS$

(c) $T\delta S = dU + pdV$

(d) None of these

$$dS = \frac{\delta Q_R}{T} \leftarrow \text{REV}$$

⑫ → Ⓒ

$$\boxed{\underbrace{Tds}_{} = \underbrace{dU + PdV}_{}}$$

ANY SYSTEM

ANY PROCESS

ANY WORKING FLUID

Q. The change in entropy is zero during

(a) Hyperbolic process

(b) Constant pressure process

(c) Reversible adiabatic process ✓ → $\boxed{S=C}$

(d) Polytropic process

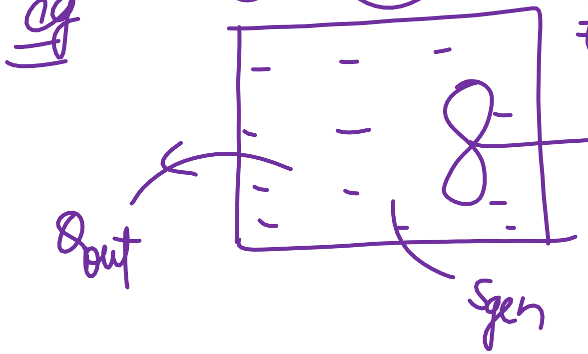
Ⓔ IRREVERSIBLE AND NON ADIABATIC PROCESS

$\Delta S = \frac{\delta Q}{T} + S_{gen} \Rightarrow \text{'}-\text{'}ve + \text{'}+\text{'}ve$

eg

$\Rightarrow -10 + 10$

$= 0$



$- S_{gen} = S_{in} - S_{out}$

$\Delta S = S_{in} - S_{out} + S_{gen}$

$\Downarrow$

0

⑬

⑭ FOR AN ISENTROPIC PROCESS → Ⓒ

Ⓐ REVERSIBLE & NON ADIA

Ⓑ IRREV & ADIA

Ⓒ NON ADIA & IRREVER

Ⓓ NONE OF THESE

Q. The main cause of the irreversibility is

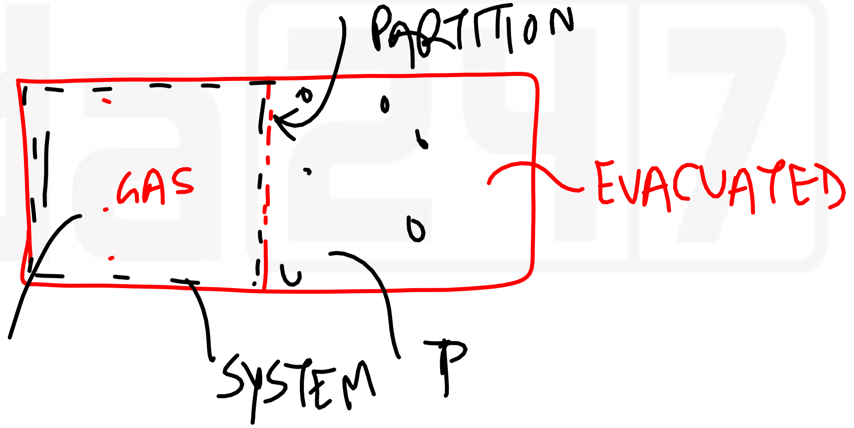
⑮ → ⓓ

(a) Mechanical and Fluid Friction

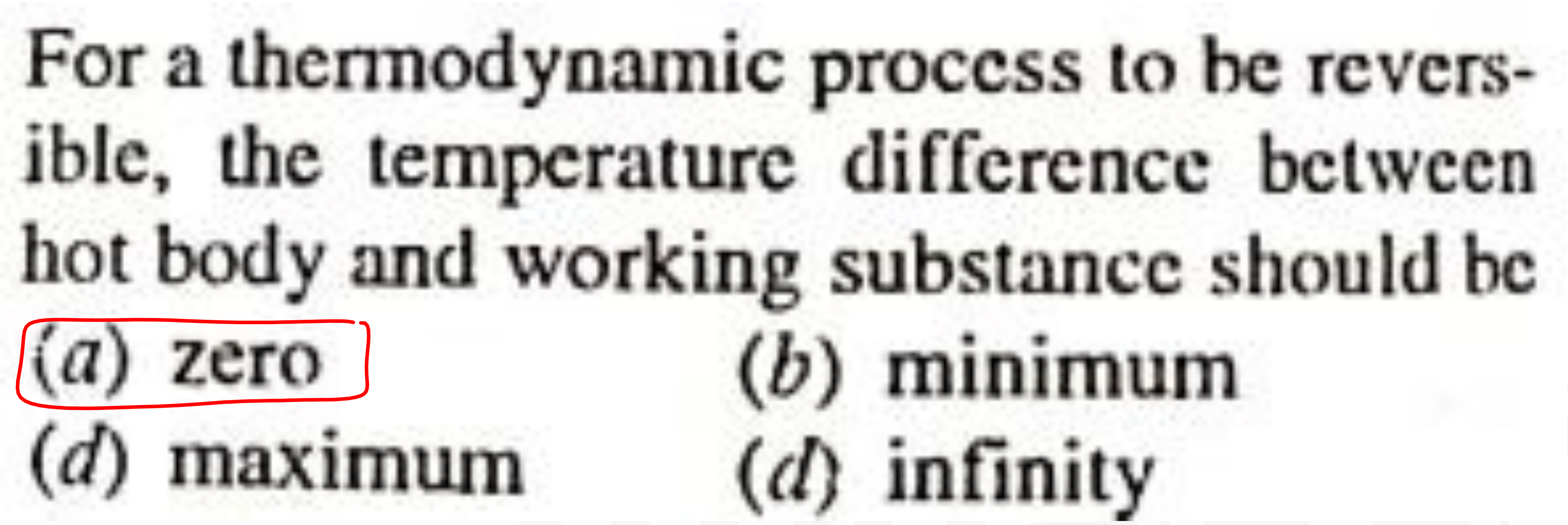
(b) Unrestricted expansion

(c)Heat transfer with a finite temperature difference

(d) All of the above



16 → a



For a thermodynamic process to be reversible, the temperature difference between hot body and working substance should be

[✓ (a) zero]
(b) minimum
(d) maximum
(d) infinity

Q. An ideal gas of mass m and temperature T1 undergoes a reversible isothermal process from an initial pressure P1 to final pressure P2. The heat loss during the process is Q. The entropy change ΔS of the gas is

⑰ → ⓑ

(a) $mR\ell n\left(\frac{P_2}{P_1}\right)$

(b) $mR\,\mathbf{ln}\left(\frac{P_1}{P_2}\right)$ ✓

(c) $\mathrm{mR}\ln\left(\frac{P_2}{P_1}\right)-\frac{Q}{T_1}$

(d) zero

$$\overset{0}{\cancel{mC_p \ln\frac{T_2}{T_1}}} - mR\ln\frac{P_2}{P_1}$$

$$= mR\ln\frac{P_1}{P_2}$$

Q. A heat engine transfers 15 kJ of heat to a thermal reservoir at 300 K. The change of entropy of the reservoir in the process is :

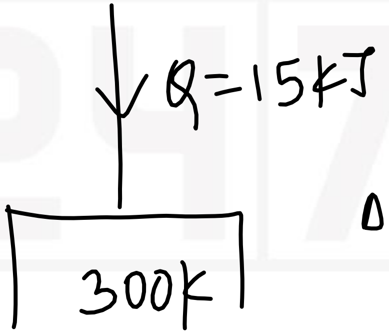
⑱

(a) $\Delta S_{\mathbf{reservoir}} = -50\mathrm{JK}^{-1}$

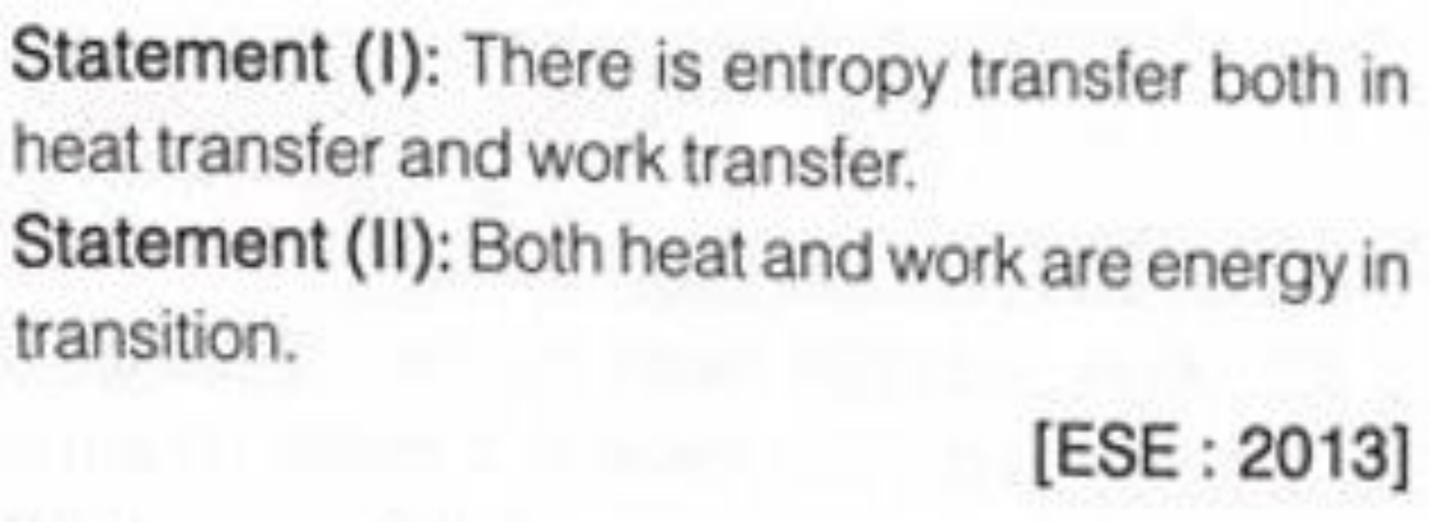
(b) $\Delta S_{\mathbf{reservoir}} = +50\mathrm{JK}^{-1}$ ✓

(c) $\Delta S_{\mathbf{reservoir}} = +200\mathrm{KJ}^{-1}$

(d) $\Delta S_{\mathbf{reservoir}} = +4500\ \mathrm{kJ.K}$



$\Delta S = \frac{\overset{5}{\cancel{15}}0\cancel{00}}{\cancel{3}\cancel{00}} = \underline{\underline{50}}$



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[ESE : 2013]

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