OCTOBER 2018/ IN-SEM (T1)

S. Y. B. TECH. (MECHANICAL ENGINEERING) (SEMESTER - I)

COURSE NAME : Thermodynamics

COURSE CODE : MEUA21175

(PATTERN 2017)

Marking Scheme

Q.1) a) Work done – 3
Heat supplied – 3

OR

b) Temperature rise, $(T_2 - T_1) = 25°C$
The heat transferred in the process, $Q = 30$ kJ
Specific heat at constant volume, $c_v = 1.2$ kJ/kg°C
Mass of the substance, $m = 2.5$ kg

$$\Delta U = m \int_{T_1}^{T_2} c_v \, dT$$

$$= 2.5 \int_{T_1}^{T_2} 1.2 \, dT = 3.0 \times (T_2 - T_1)$$

$$= 3.0 \times 25 = 75 \text{ kJ}$$

Hence, **the change in internal energy is 75 kJ. (Ans.)**
According to the first law of thermodynamics,

$$Q = \Delta U + W$$
$$30 = 75 + W$$
$$W = 30 - 75 = -45 \text{ kJ}$$

Hence, **the work done = – 45 kJ. (Ans.)**
It may be observed that *even though the volume is constant the work is not zero.*
Clearly, the process is **irreversible.**

change in internal energy – 2
Work done – 2
Correct formula – 2

Q.2) a) Definition – 2
COP Refrigerator – 2
COP Heat pump – 2

OR

b) Temperature of furnace gases, $T_1 = 2100 + 273 = 2373$ K

Temperature of cooling water, $T_2 = 15 + 273 = 288$ K

$$\eta_{max} \ (= \eta_{carnot}) = 1 - \frac{T_2}{T_1} = 1 - \frac{288}{2373}$$

= 0.878 or 87.8%.

Max. efficiency - 5
Correct formula – 1

Q.3) a) Derivation – 6

OR

b) Given :
$m = 4$ kg
$T_1 = 127 + 273 = 400$ K
$T_2 = 227 + 273 = 500$ K
$c_v = (0.48 + 0.0096\,T)$ kJ/kg K

Entropy variation for a constant volume process is given by :

$$dS = mc_v \frac{dT}{T}, \quad \text{or,} \quad dS = 4 \times (0.48 + 0.0096T) \frac{dT}{T}$$

Integrating both sides, we get,

$$S_2 - S_1 = 4 \times 0.48 \int_{T_1}^{T_2} dT + 4 \times 0.0096 \int_{T_1}^{T_2} dT$$

$$= 1.92 \log_e \left(\frac{T_2}{T_1}\right) + 0.0384\,(T_2 - T_1)$$

$$= 1.92 \log_e \left(\frac{500}{400}\right) + 0.0384(500 - 400) = 4.268 \text{ kJ/K}$$

$$\mathbf{S_2 - S_1 = 4.268 \text{ kJ.}} \quad \textbf{(Ans.)}$$

Change in entropy – 4
Correct formula – 2

Q.4) a) Diagram – 2
Explanation – 2

OR

b) Diagram – 2
Explanation – 2

Q.5) a) Given: Height of chimney, $H = 20$ m, $T_g = 653$ K, $T_a = 300$ K

For maximum discharge condition,

$$\frac{T_g}{T_a} = 2\left(\frac{m+1}{m}\right)$$

$$2\left(1+\frac{1}{m}\right) = \frac{653}{300}$$

$$m = 11.32 \text{ kg air per kg of fuel}$$

Air supplied = 11.32 kg/kg of fuel *Ans.*

Draught in mm of water column

$$h_w = 353 \times 20\left[\frac{1}{300} - \left(\frac{11.32+1}{11.32}\right)\cdot\frac{1}{653}\right]$$

$$h_w = 11.77 \text{ mm of water}$$

Draught = 11.77 mm of water *Ans.*

Air supplied – 2

Draught – 2

Correct formula – 2

b) For every point – 1

c) For every point – 1

OR

Q.6) a)

Heat supplied	*kJ*	*Heat consumed*	*kJ*	*%*
Heat supplied in 1 kg of coal	34 272	1. Heat utilised in raising steam.	22 428	65.44
		2. Heat carried away by dry flue gases.	5116	14.93
		3. Heat lost in moisture.	121	0.35
		4. Heat lost in radiation, etc. (by difference)	6607	19.28
Total	34 272	Total	34 272	100

For every point - 1

b) For every point – 2
(definition, mathematical expression)

c) For every point – 1

Q.7) a) (i) Temperature at the end of compression T_2

For compression process 1-2, we have

$$\frac{T_2}{T_1} = \left(\frac{P_2}{P_1}\right)^{\frac{n-1}{n}} = \left(\frac{10}{1}\right)^{\frac{1.2-1}{1.2}} = 1.468$$

$T_2 = T_1 \times 1.468 = 293 \times 1.468 = 430$ K or 157°C

(ii) Workdone and heat transferred during compression per kg of air:

$$\text{Workdone, } W = mRT_1 \frac{n}{n-1}\left[\left(\frac{P_2}{P_1}\right)^{\frac{n-1}{n}} - 1\right]$$

$$= 1 \times 0.287 \times 293 \times \left(\frac{1.2}{1.2-1}\right)\left(\frac{10}{1}\right)^{\frac{1.2-1}{1.2}} - 1 = 236.13 kJ/kg\ of air$$

Heat transferred during compression,

$$Q = W + \Delta U$$

$$= \frac{p_1 v_1 - p_2 v_2}{n-1} + c_v(T_2 - T_1) = (T_2 - T_1)\left[c_v - \frac{R}{n-1}\right]$$

$$= (430-293)\left[0.718 - \frac{0.287}{1.2-1}\right] = -98.23 \text{ kJ/kg}$$

Negative sign indicates heat is rejected

b) Temperature – 2
Work done – 2
Heat transfer – 2
For correct formula - 1 each

c) For correct diagram – 2 each

OR

Q.8) a) For double acting compressor average piston speed = 2LN

$\therefore$ 2LN = 150 m/min

$$\therefore L = \frac{150}{2 \times 1.5 \times 60} = 0.833m$$

L = 0.833 m

To Find D

$IP = W.N_W$

where

N_w = Number of working stroke

For Double acting $N_W = 2N$

For single acting $N_W = N$

$\therefore N_W = 2 \times 1.5 \times 60 = 180$ rpm

$$\therefore W.D/cycle = \frac{n}{n-1} p_1 V_1 \left[\left(\frac{p_2}{p_1} \right)^{\frac{n-1}{n}} - 1 \right]$$

$$= \frac{1.2}{1.2-1} \times 100 \times 10^3 \left(\frac{\pi}{4} D^2 \times 0.833 \right) \times \left[\left(\frac{(500)}{100} \right)^{\frac{0.2}{1.2}} - 1 \right]$$

$W = 120764.2D^2$ N-m

$$\therefore IP = \frac{W.N_w}{60}$$

$$50 \times 10^3 = \frac{1207642 D^2 \times 180}{60}$$

$D^2 = 0.1380$

$D = 0.371$ m

Stroke – 2
Diameter – 2
Correct formula – 2

b) For every point – 1

c) Diagram – 2
Processes – 2