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PTQ
Prelims Through Questions
for
ESE 2021

Mechanical Engineering

Day 11 of 11

Q.451 - Q.500
(Out of 500 Questions)

Production Engg. + Material Science + Thermodynamics + Refrigeration & Air-Conditioning

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Q.451 Which of the following statements is(are) correct?
1. Muntz metal is consist of 60% copper and 40% zinc.
2. Muntz metal is also known as brown metal.
(a) 1 only
(b) 2 only
(c) 1 and 2
(d) neither 1 nor 2

451. **(a)**
Muntz metal or yellow metal is consist of 60% copper and 40% zinc. It is used as a brazing alloy for steel.

Q.452 Consider the following statements as advantages and characteristics of hot working relative to cold working:
1. More significant shape changes are possible.
2. Coefficient of friction is reduced.
3. Fracture of work part is less likely.
4. Less overall energy is required.
5. Lower deformation forces is required.
Which of the following statements are CORRECT?
(a) 2, 3 and 4 only
(b) 1, 3, 4 and 5 only
(c) 1, 3 and 5 only
(d) 1, 2 and 4 only

452. **(c)**
In hot working process following advantages are:
Advantages:
• The shape of workpart can be significantly altered.
• Lower forces and power are required to deform the metal.
• Fracture of work part is less likely.
Disadvantages:
• Lower dimensional accuracy.
• Higher total energy required (due to the thermal energy to heat the work piece).
• Work surface oxidation, sticking tendency and poor surface finish therefore friction will be more.
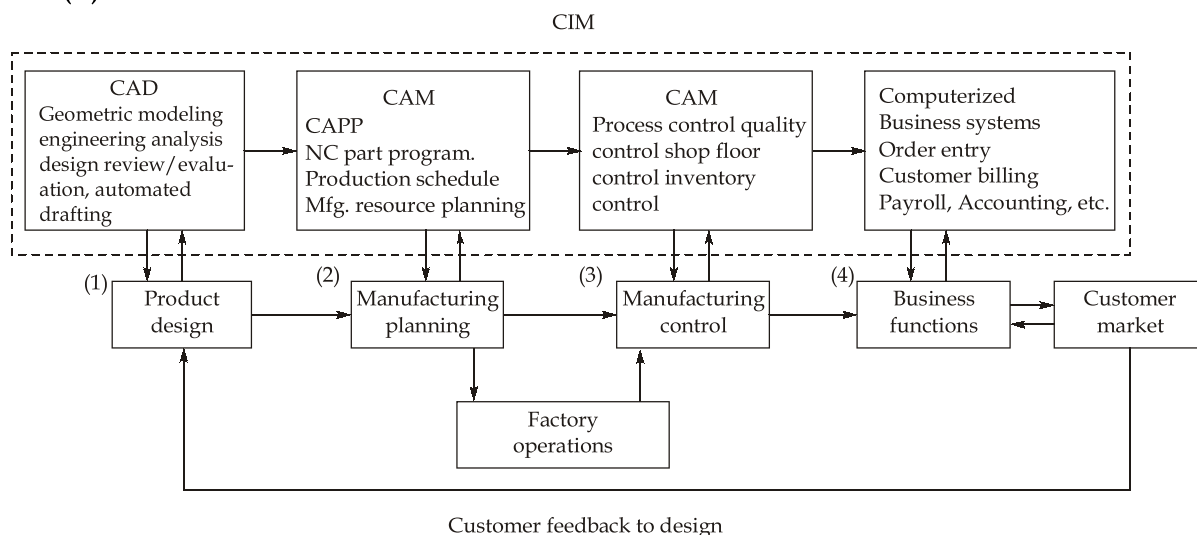• Shorter tool life.

Q.453 Consider the following statements regarding computer integrated manufacturing (CIM):
1. CIM is the combination of product design, manufacturing planning, manufacturing control and business functions.
2. Computer system that associated with product design which is known by CAD system.
3. Computer systems that support manufacturing planning is known by CAM system.
4. Computer system associated with business function that is known by computerized business systems.

Choose the correct statements:

(a) 1, 3 and 4 only   (b) 2, 3 and 4 only

(c) 1, 2 and 3 only   (d) 1, 2, 3 and 4

453. **(d)**

CIM

| (1) Product design | (2) Manufacturing planning | (3) Manufacturing control | (4) Business functions — Customer market |

Factory operations

Customer feedback to design

Q.454 A mold sprue is 20 cm long and the cross-sectional area at its base is 2.5 cm^2. The sprue feeds a horizontal runner leading into a mold cavity whose volume is 1800 cm^3 then required time to fill the mold is: (Assume, g = 10 m/s^2)

(a) 36 s   (b) 3.6 s

(c) 3.64 s   (d) 36.4 s

454. **(b)**

the velocity of the flowing metal at the base of the sprue.

Velocity of flow, $V = \sqrt{2gh}$

Velocity of flow, $V = \sqrt{2 \times 1000 \times 20} = 200$ cm/s

Volume flow rate $(Q) = A \times V = 2.5$ cm$^2 \times 200$ cm/s $= 500$ cm^3/s

Time required to fill a mold cavity $= \dfrac{\text{Volume of mold cavity}}{\text{Volume flow rate}} = \dfrac{1800}{500} = 3.6$ s

Q.455 If a MIG welding process is performed by considering the following parameters:

Current, I = 260A, Voltage, V = 25V

Welding speed = 15 cm/min

Wire diameter = 1.5 mm

Wire feed rate = 2.5 m/min

Thermal efficiency = 0.75,

What will be the area of cross-section of weld?

(a) 15.34 mm^2 (b) 20.45 mm^2

(c) 25.54 mm^2 (d) 29.45 mm^2

455. **(d)**
As per the given data,

Volume flow rate of weld metal = $\frac{\pi}{4} \times d^2 \times$ wire feed rate

$$= \frac{\pi}{4} \times 1.5^2 \times 2.5 \times 1000$$
$$= 4417.864 \text{ mm}^3/\text{min}$$

Area of weld = $\dfrac{\text{Volume flow rate of weld metal}}{\text{Welding speed}}$

$$= \frac{4417.864}{150} \frac{\left(\text{mm}^3/\text{min}\right)}{\left(\text{mm}/\text{min}\right)} = 29.45 \text{ mm}^2$$

Q.456 A symmetrical cup of circular cross-section with 40 mm diameter and 60 mm height, with a corner radius of 2 mm is to be obtained from mild steel blank of 0.6 mm thickness. Then the required size of blank is:
(a) 102.83 mm (b) 105.83 mm
(c) 108.83 mm (d) 110.83 mm

456. **(b)**
As per given data,
Cup diameter, d = 40 mm; Height, h = 60 mm; Corner radius; r_c = 2 mm;
Blank thickness, t = 0.6 mm

Required blank diameter = $\sqrt{d^2 + 4\,d\,h}$

$$= \sqrt{40^2 + 4 \times 40 \times 60} = \sqrt{1600 + 9600} = 105.83 \text{ mm}$$

Q.457 The modulus of elasticity of nonporous ceramic material is 100 GPa. Then the modulus of elasticity of a ceramic material having volume fraction porosity of 10% is
(a) 81.9 GPa (b) 90 GPa
(c) 94 GPa (d) 87.6 GPa

457. **(a)**
Given, Nonporous ceramic material modulus of elasticity, E_O = 100 GPa
Volume fraction porosity, P = 10%
We know that, Modulus of elasticity of porous ceramic material,
$$E = E_O(1 - 1.9P + 0.9P^2)$$
$$= 100(1 - 1.9 \times 0.1 + 0.9 \times 0.1^2)$$
$$= 100(1 - 0.19 + 0.009) = 100 \times 0.819$$
$$E = 81.9 \text{ GPa}$$

Q.458 A metal having FCC crystal structure has an edge length of 0.4 nm and atomic weight as 64 g/mol. Then the density of the metal is
(a) 3.73×10^3 kg/m^3 (b) 4.98×10^3 kg/m^3
(c) 3.32×10^3 kg/m^3 (d) 6.64×10^3 kg/m^3

458. **(d)**

Given: Edge length, a = 0.4 nm = 4×10^{-8} cm

Number of atoms per unit cell, n = 4

Atomic weight, A = 64 g/mol

Avogadro's number, N_A = 6.023×10^{23} atoms/mol

Volume of unit cell, V_C = $a^3 = (4 \times 10^{-8})^3 = 64 \times 10^{-24}$ cm^3

We know that,

$$\text{Density, } \rho = \frac{nA}{(V_c)(N_A)} = \frac{4 \times 64}{64 \times 10^{-24} \times 6.023 \times 10^{23}}$$

$$= \frac{40}{6.023} = 6.64 \text{ g/cm}^3 = 6.64 \times 10^3 \text{ kg/m}^3$$

Q.459 Which of the following is true regarding full annealing process?

1. Material is exposed to elevated temperature for a fixed time period.
2. Material is cooled slowly in furnace.
3. Full annealing processes is mainly used for increasing the machinability of high carbon steels.

(a) 1 and 2   (b) 2 and 3

(c) 1 and 3   (d) 1, 2 and 3

459. **(a)**

In full annealing process material is exposed to an elevated temperature for an extended time period and then slowly cooled in the furnace. Full annealing is mainly used for reducing the hardness or brittleness or to increase the ductility or toughness.

Note: Spheroidise annealing is mainly used for increasing the machinability of medium and high carbon steels.

Q.460 In an electrochemical machining process with a pure iron workpiece having density 7.8 g/cm^3, atomic weight 56 g and valency of 2, a removal rate of 6 cm^3/min is desired. What is the current required?

(a) 2688 Ampere   (b) 2610 Ampere

(c) 101435 Ampere   (d) 161293 Ampere

460. **(a)**

We know that,

$$\text{Volumetric removal rate } \dot{Q} = \frac{AI}{ZF\rho} \text{ cm}^3/\text{sec}$$

Where, A = Gram atomic weight of ion

I = Current (Amperes)

ρ = Density of anode (g/cm^3)

Z = Valency of the anode

F = Faraday constant (96500 Coulombs)

So,

$$\frac{6}{60} = \frac{56 \times I}{2 \times 96500 \times 7.8}$$

$$I = \frac{2 \times 96500 \times 7.8}{10 \times 56} = 2688.2 \text{ Amperes}$$

Q.461 What type of flame in gas welding is used for copper and copper alloys?

(a) Oxidizing flame   (b) Neutral flame

(c) Reducing frame   (d) Reducing and oxidizing flame both

461. **(a)**

Oxidizing flame is used for copper and copper alloys because it gives high temperature and high heat input. As copper is having high thermal conductivity. So, fast heat dissipation takes place, so high heat input is required.

Q.462 In a selective assembly of some parts (shafts and holes), the desired tolerance for both shaft and holes is 0.3 mm. The process capability of the machine is 0.9 mm. What is the number of groups made for selective assembly?

(a) 0.66   (b) 0.33

(c) 3   (d) 1.5

462. **(c)**

$$\text{Number of groups} = \frac{\text{Process capability}}{\text{Tolerance desired}} = \frac{0.9}{0.3} = 3$$

Q.463 Which one of the following is the correct curve between material removal rate (MRR) and nozzle tip distance in abrasive jet machining?
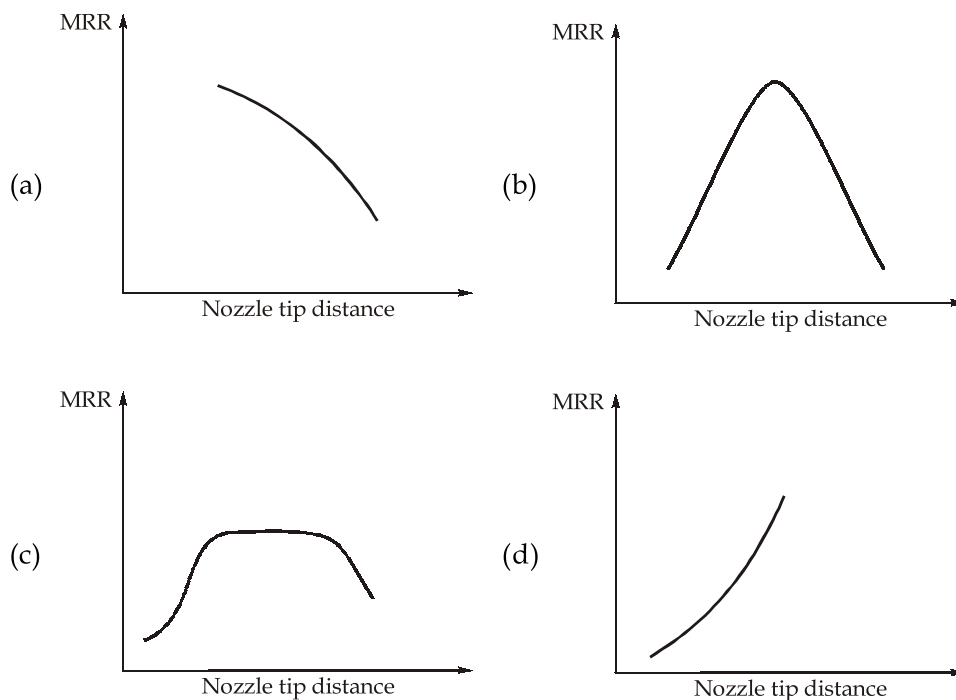
463. **(c)**

Q.464 Cellular manufacturing is the type of _____

(a) Functional layout   (b) Product layout

(c) Group layout   (d) None of these

464. **(c)**

The machines in cellular manufacturing are arranged in an efficient product flow line called group layout. The manufacturing cell layout depends on the common features in parts, thus group technology is an essential feature for designing cells and therefore for implementing lean manufacturing.

Q.465 In a plain indexing of milling operation, what should be the rotation for 28 division, if 40 revolution of the index crank produces one full revolution of the workpiece?

(a) 1 full rotation + 9 holes in a 21-hole circle
(b) 2 full rotation + 9 holes in a 21-hole circle
(c) 1 full rotation + 22 holes in a 49-hole circle
(d) 2 full rotation + 22 holes in a 49-hole circle

465. **(a)**

Rotation of the index crank = $\dfrac{40}{28} = 1\dfrac{3}{7}$

This can be done as

1 full rotation + 9 holes in a 21-hole circle

or

1 full rotation + 21 holes in a 49-hole circle

Q.466 Which one of the following is not the advantage of down milling?

(a) Better surface finish
(b) Good for thin parts
(c) Useful for machining castings or hot rolled steel
(d) Climb milling allows greater feeds per tooth

466. **(c)**

Advantages of down milling:

1. Climb or down milling is good for thin and frail workpiece.
2. In down milling, though the cut starts with a full chip thickness, the cut gradually reduces to zero. This helps in eliminating the feed marks as present in the case of up milling and consequently results in better surface finish.
3. Climb milling also allows greater feeds per tooth and longer cutting life between regrinds than the conventional (up) milling.

Disadvantages:

1. It cannot be used for machining castings or hot rolled steel, since the hard outer scale will damage the cutter.
2. It cannot be used unless the machine has a backlash eliminator and the table jigs have been tightened.

Q.467 A part measuring (250 mm × 100 mm × 40 mm) is to be machined using a hydraulic shaper along its wide face (250 mm × 100 mm). If cutting speed and return speed is 6 m/min, a machining allowance on either side of the plate width is 5 mm, feed is 1 mm/stroke and approach as well as over travel is 25 mm each. What is the machining time?

(a) 11 minutes   (b) 10 minutes
(c) 5.5 minutes   (d) 5 minutes

467. **(a)**

Given: Approach and over travel distance = 25 mm,

Length of the stroke = 250 + 25 + 25 = 300 mm

Width of the plate to be completed = 100 + 5 + 5 = 110 mm

Number of strokes required = $\dfrac{\text{Width}}{\text{Feed}} = \dfrac{110}{1} = 110$

[Given, feed/stroke = 1 mm/stroke]

Time for one stroke, T is

$$T = \frac{\text{Total length}}{\text{Cutting speed}} = \frac{2 \times 300}{6 \times 1000} = 0.1 \text{ minute}$$

Total machining time = 0.1 × 110 = 11 minutes

Q.468 A shielded metal arc welding operation takes place on a steel workpiece with 30 V power supply. If a weld with a triangular cross-section having leg length and height both of 10 mm is to be produced. What will be the current needed for a welding speed of 10 mm/s? Use thermal efficiency of 80%. The specific energy needed to melt the steel electrode is 10.5 J/mm³.

(a) 118.75 A (b) 218.75 A

(c) 318.75 A (d) 418.75 A

468. **(b)**

$$\text{Area, } A = \frac{1}{2}b \times h = \frac{1}{2} \times 10 \times 10 = 50 \text{ mm}^2$$

We know, that, $\quad v = \dfrac{\eta VI}{u \times A}$

Where, $\quad v$ = Speed (mm/s); η = Efficiency; V = Voltage (V); I = Current (A);

u = Specific energy (J/mm³)

A = Area (mm²)

$$10 = \frac{0.80 \times 30 \times I}{10.5 \times 50}$$

$$I = 218.75 \text{ A}$$

Q.469 Consider the following statements about wire drawing of steel:

1. To ensure required ductility, workpiece heated to temperature 600°C and then cooled in lead bath of 300°C.
2. Proper cleaning is done by acid pickling.
3. For high temperature condition, copper and tin are used for lubrication.

Which of the above statements are correct?

(a) 1, 2 and 3 (b) 2 and 3

(c) 1 and 3 (d) 1 and 2

469. **(b)**

To ensure ductility, annealing is done. Workpiece is heated above A_{C3} i.e. 900-950° around 30 min to 1 hr then after heating or annealing cooling is done in lead bath of temperature 300°C.

Q.470 The maximum possible draft, Δh as a function of the roll radius, R, and the coefficient of friction, μ is defined as
(a) $\Delta h = \mu^2 R$ (b) $\Delta h = \mu R$
(c) $\Delta h = 0.5\mu^2 R$ (d) $\Delta h = \mu R^2$

470. **(a)**

Q.471 A glass fiber-reinforced composite consists of 40% of glass fibre having modulus of elasticity of 69 GPa and 60% of a polyester resin that has a modulus of elasticity of 3.4 GPa. What is the value of modulus of elasticity of composite in transverse direction?
(a) 4.5 GPa   (b) 6.5 GPa
(c) 7.5 GPa   (d) 5.5 GPa

471. **(d)**

$$E_m = 3.4 \text{ GPa},$$
$$V_m = 0.6$$
$$E_f = 69 \text{ GPa},$$
$$V_f = 0.4$$
$$E_{ct} = \frac{E_m \times E_f}{V_m E_f + V_f E_m} = \frac{3.4 \times 69}{0.6 \times 69 + 0.4 \times 3.4} = 5.48 \text{ GPa}$$

Q.472 Which of the following options is incorrect?
(a) Carbon nanotubes are extremely strong, stiff and relatively ductile.
(b) Carbon nanotube has been termed as ultimate fibre and is extremely promising as a reinforcement in composite materials.
(c) Carbon nanotubes have relatively higher densities.
(d) Carbon nanotubes have structure-sensitive electrical properties.

472. **(c)**
- The structure of carbon nanotube consists of a single sheet of graphite, rolled into a tube, both end of which are capped with C_{60} fullerene hemisphere.
- They have relatively low densities.
- By structure-sensitive electrical properties means depending on the orientation of hexagonal units in the graphene plane (i.e. tube wall) with the tube axis. The nanotube may behave electrically as either a metal or a semiconductor.

Q.473 Which one of the following statements is not correct?
(a) The ability of a metal to plastically deform depends on the ability of dislocations to move.
(b) The principle of strengthening techniques is restricting or hindering dislocation motion renders a material harder and stronger.
(c) The atomic disorder within a grain boundary region will result in a discontinuity of slip planes from one grain into the other.
(d) High-purity metals are almost always stronger and harder than alloys composed of the same base metal.

473. **(d)**
High purity metals are almost always softer and weaker than alloys composed of the same base metal.

Q.474 In an invariant reaction involving three phases at equilibrium, upon heating one solid phase transforms into a liquid phase and another solid phase. What is name of invariant reaction?
(a) Monotectic reaction
(b) Peritectoid reaction
(c) Peritectic reaction
(d) Monotectoid reaction

474. **(c)**

Peritectic reaction $\Rightarrow S + L \xrightleftharpoons[\text{Heating}]{\text{Cooling}} S$
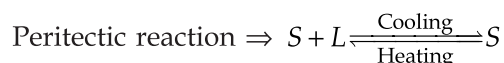
A peritectic reaction exists for copper-zinc system at 598°C (1108°C) and 78.6 Wt% Zn - 21.4 Wt% Cu.

Q.475 Consider the following statements regarding phases:
1. When two phases are present in a system, it is necessary that there be a difference in both physical and chemical properties.
2. Phases can be both homogeneous and heterogeneous.
3. Every pure metal is considered to be a phase; so also is every solid, liquid and gaseous solution.
4. When a substance exists in two or more polymorphic forms (eg. having both FCC and BCC structures), each of these structures is a separate phase.
Which of the above statements are correct?
(a) 2 and 3
(b) 1 and 3
(c) 3 and 4
(d) 1 and 4

475. **(c)**
• When two phases are present in a system, it is not necessary that there be a difference in both physical and chemical properties; a disparity in one or the other set of properties is sufficient.
• When water and ice are present in a container, two separate phase exists, they are physically dissimilar but identical in chemical makeup.

Q.476 Consider the following statements regarding galvanic corrosion:
1. If the coupling of dissimilar metals is necessary, choose two that are close together in the galvanic series to reduce the rate of galvanic corrosion.
2. Use anode area as small as possible to decrease the rate of galvanic attack for given cathode area.
3. Corrosion rate is independent of current density.
4. Electrically insulate dissimilar metals from each other to reduce the effects of galvanic corrosion.
Which of these statements are correct?
(a) 1 and 4
(b) 2 and 3
(c) 3 and 4
(d) 1 and 3

476. **(a)**
To reduce the rate of galvanic attack, anode area should be as large as possible.
The reason for this is that corrosion rate depends on current density, i.e. the current per unit area of corroding surface, and not simply the current. Thus, this results in high current density for the anode when its area is small relative to that of cathode.

Q.477 Availability function of a steady flow system is expressed as:

(a) $\psi = u + p_o v - T_o s$

(b) $\psi = h + \dfrac{V^2}{2} + gZ - T_o s$

(c) $\psi = h + p_o v - T_o s$

(d) $\psi = du + p_o dv - T_o s$

477. **(b)**

For steady flow system,

Exergy function, $\psi = h - T_o s + \dfrac{V^2}{2} + gZ$

Q.478 Consider the following statements about compressibility factor (z):
1. Its value is one for ideal gas.
2. Its value may be less than 0, more than 0 or equal to 0.
3. A value of z-less than 1 signifies that gas is difficult to compress as compared to ideal gas.
4. At low temperatures and only moderately high pressures, Z can be more than 1.
Which of the above statements is(are) correct?

(a) 1 only

(b) 2 only

(c) 1, 2 and 3

(d) 1, 2, 3 and 4

478. **(a)**

z is 1 for ideal gas.

z may be less than 1, more than 1 or equal to 1.

If $z < 1$, attraction dominates and gas is easier to compress as compared to ideal gas.

At low temperatures and only moderately high pressures, Z can be less than 1.

Q.479 Two Carnot heat engines are operating in series. The source temperature and sink temperature of the first engine are 2500 K and 500 K respectively. If thermal efficiency of second engine is 0.6 times the thermal efficiency of first engine, the sink temperature of second engine is:

(a) 180 K

(b) 100 K

(c) 210 K

(d) 260 K

479. **(d)**
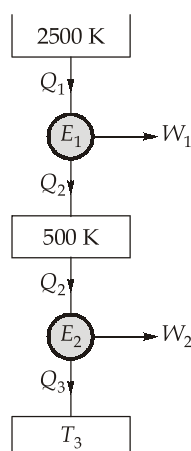
Thermal efficiency of Ist engine,

$$\eta_I = 1 - \frac{T_2}{T_1} = 1 - \frac{500}{2500} = 0.8$$

As per the question, $\eta_{II} = 0.6\,\eta_I = 0.6 \times 0.8 = 0.48$

$$0.48 = 1 - \frac{T_3}{500}$$

$$\Rightarrow \qquad 1 - 0.48 = \frac{T_3}{500}$$

$$T_3 = 0.52 \times 500 = 260 \text{ K}$$

Q.480 Consider the following statements:

1. Entropy is a conserved property.
2. Spontaneous processes in nature occur only in one direction.
3. Entropy generation is the measure of irreversibilities during a process.

Which of these statements are correct?

(a) 2 and 3 only   (b) 1 and 3 only

(c) 1 and 2 only   (d) 1, 2 and 3

480.   (a)

Entropy is conserved during reversible processes only and increases during irreversible process.
A process occurs in the direction that complies with the increase of entropy principle.
Entropy generation is the measure of irreversibilities. The greater the extent of irreversibilities, the greater the entropy generation.

Q.481 Consider the following processes:

1. Heat transfer through a finite temperature difference.
2. Unrestrained expansion of a gas to a lower pressure.
3. Spontaneous chemical reaction.
4. Elastic deformation

Which of the above processes are irreversible?

(a) 1, 2 and 3   (b) 2, 3 and 4

(c) 1, 3 and 4   (d) 1, 2, 3 and 4

481.   (a)

Elastic deformation is fully reversed (or recovered) when load is removed and hence is a reversible process.

Q.482 The performance test of an air conditioning unit rated as 50 TR seems to be working poorly. The test on heat rejection to atmosphere in its condenser shows the following:

Cooling water flow rate: 5l/s

Water temperatures: In 30°C, out 38°C

Power input to motor: 50 kW (90% efficiency of motor)

What is the difference between actual refrigerating capacity and rated capacity?

(a) 52.8 kW   (b) 63.35 kW

(c) 7.8 kW   (d) Can't be calculated

482. **(a)**

Rated refrigerating capacity = 50 TR = 50 × 3.5 = 175 kW

Heat rejected, $\dot{Q}_{out}$ = $\dot{m}_{water} c_{water} (\Delta T)$

= (5 × 10⁻³ × 10³) kg/s × (4.18) kJ/kg-°C × (38 – 30)°C

= 5 × 4.18 × 8 = 167.2 kW

Work input to cycle, W = 50 × 0.9 = 45 kW

Actual refrigeration capacity, $\dot{Q}_{in}$ = $\dot{Q}_{out} - W$ = 167.2 – 45 = 122.2 kW

Difference in actual and rated capacity = 175 – 122.2 = 52.8 kW

Q.483 Which of the following graph correctly represent a VCRS cycle on the P-h diagram?

(a)

(b)

(c)

(d)
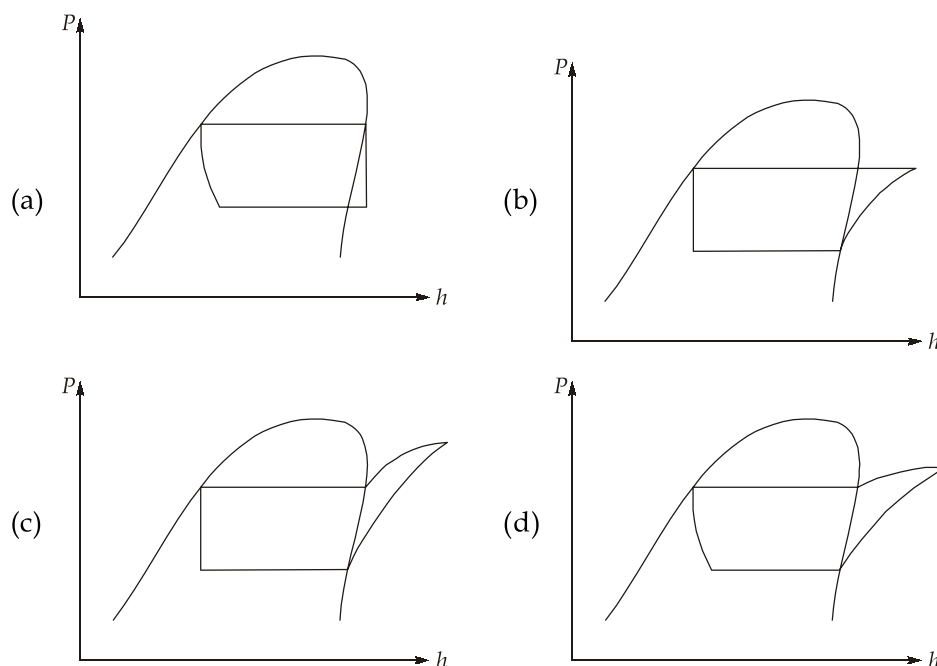
483. **(b)**

Q.484 A heat pump working on simple VCR cycle with refrigerant 134a (Tetrafluoroethane) used for space heating operates between temperature limits of 15°C in evaporator and 50°C in condenser. The heat required to be pumped is 120 MJ/h.

Saturation (T°C)	Pressure (MN/m²)	Specific enthalpy		Specific entropy	
		h_f (kJ/kg)	h_g (kJ/kg)	s_f (kJ/kgK)	s_g (kJ/kgK)
15	0.4887	220.48	417.10	1.0725	1.72
50	1.318	271.62	423.40	1.24	1.7072

What will be the dryness fraction of refrigerant entering the evaporator?

(a) 0.24   (b) 0.26

(c) 0.94   (d) 0.98

484. **(b)**

As the expansion is isenthalpic process, enthalpy will be equal at entry and exit of expansion device.

$$271.62 = 220.48 + x(417.1 - 220.48)$$

$$\Rightarrow \qquad x = \frac{51.14}{196.62} = 0.26$$

Q.485 Which of the following is the correct designation of refrigerant ethylene?

(a) R17 (b) R15

(c) R1130 (d) R1150

485. **(d)**

Ethylene is C_2H_4 which is an unsaturated compound.

Number of carbon atoms, $m = 2$

Number of hydrogen atoms, $n = 4$

Number of fluorine atom, $p = 0$

Number of chlorine atom, $q = 0$

So, designation will be:

$R1\ (m - 1)\ (n + 1)p$

i.e. $R1\ (2 - 1)\ (4 + 1)0$

i.e. R1150

Q.486 Gas is compressed polytropically $\left(n = \dfrac{8}{7}\right)$ from 1 bar to $(1.5)^4$ bar in a reciprocating compressor with 10 percent clearance and swept volume of 2 m³. If the exponent of the re-expansion curve is $\dfrac{4}{3}$ instead of $\dfrac{8}{7}$, what will be the compressor work?

(a) 252 kJ (b) 352 kJ

(c) 297 kJ (d) 812 kJ

486. **(a)**

Given, $V_1 - V_3 = 2$ m³, $\qquad \dfrac{V_3}{V_1 - V_3} = 0.10$

$$n = \frac{8}{7},\ m = \frac{4}{3}$$

$$P_1 = 1 \text{ bar} \qquad P_2 = (1.5)^4 \text{ bar}$$
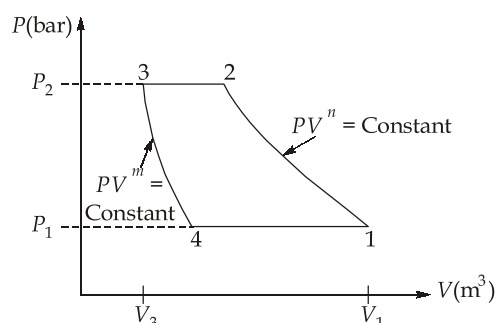
$$V_3 = 0.1 \times 2 \text{ m}^3 = 0.2 \text{ m}^3$$

$$V_1 = 2 + V_3 = 2 + 0.2 = 2.2 \text{ m}^3$$

$$V_4 = V_3\left(\frac{P_3}{P_4}\right)^{1/m} = V_3\left(\frac{P_2}{P_1}\right)^{1/m}$$

$$= 0.2\left(\frac{(1.5)^4}{1}\right)^{3/4}$$

$$= 0.2 \times 1.5^3 = 0.2 \times 1.5 \times 2.25 = 0.3 \times 2.25$$

$$= 0.675 \text{ m}^3$$

$$W = \frac{n}{n-1}P_1V_1\left[\left(\frac{P_2}{P_1}\right)^{(n-1)/n} - 1\right] - \frac{m}{m-1}P_1V_4\left[\left(\frac{P_2}{P_1}\right)^{(m-1)/m} - 1\right]$$

$$= \frac{\frac{8}{7}}{\frac{8}{7}-1} \times 100 \times 2.2\left[\left(\frac{(1.5)^4}{1}\right)^{\frac{\frac{8}{7}-1}{\frac{8}{7}}} - 1\right] - \frac{\frac{4}{3}}{\frac{4}{3}-1} \times 100 \times 0.675\left[\left(\frac{(1.5)^4}{1}\right)^{\frac{\frac{4}{3}-1}{\frac{4}{3}}} - 1\right]$$

$$= \frac{8}{1} \times 220\left(1.5^{1/2} - 1\right) - \frac{4}{1} \times 67.5(1.5 - 1)$$

$$= 1760\ (1.22 - 1) - 270 \times 0.5$$

$$= 387.2 - 135 = 252.2\ kJ$$

Q.487 Which of the following statements are Incorrect?

1. A process is reversible only if it is both internally and externally reversible.
2. An isentropic process is always reversible adiabatic.
3. If entropy is generated in universe, then always the entropy of universe has to be constant.
4. When the heat is rejected from a system, then the process cannot be of constant entropy.

(a) 1, 2, and 3
(b) 2, 3 and 4
(c) 1, 3 and 4
(d) 1, 2, 3 and 4

487.   (b)

- A reversible adiabatic process is always isentropic but an isentropic process is not always reversible adiabatic.
- If entropy is generated in universe, then entropy of universe always increases.
- For a process entropy can increase, decrease or remains constant.

Q.488 Consider the following statements regarding second law efficiency.

1. The second law efficiency of all reversible devices cannot be 100%.
2. The second law efficiency of naturally occurring process is zero if none of the work potential is recovered.

Which of the following is/are correct?

(a) 1 only
(b) 2 only
(c) 1 and 2
(d) none of these

488.   (b)

The second law efficiency of all reversible devices is 100%.

$$\eta_{II} = \frac{W_{useful\ work\ output}}{W_{reversible}} \quad \text{(work producing devices)}$$

$$\therefore \quad W_{reversible} = W_{useful}\ \text{(for reversible process)}$$

$$\eta_{II} = 100\%$$

Similarly,

$$\eta_{II} = \frac{W_{reversible}}{W_{useful\ work\ output}}\ \text{(work consuming devices)}$$

$$\therefore \quad W_{reversible} = W_{useful} \quad \text{(for reversible devices)}$$

$$\eta_{II} = 100\%$$

$$\eta_{II} = \frac{\text{Exergy recovered}}{\text{Exergy supplied}}$$

if   exergy recovered = 0

$$\eta_{II} = 0$$

Q.489 Consider the following
1.   Intensive property – specific heat.
2.   Extensive property – heat capacity.
3.   Path function – entropy generation.
4.   Open system – human body.
Which of the following items is/are incorrectly matched?
(a) 2 and 4   (b) 2 and 3
(c) 4 only   (d) none of the above

489.   (d)
(i)   Entropy is a property but entropy generation is not a property and is a path function.
(ii) Human body is an open system by the strict thermodynamic definition because it exchanges energy with its surroundings (heat and work), and material in the form of gases, food, waste products, water.

Q.490 Helium in a piston cylinder arrangement goes through a polytropic process with heat to work ratio of 0.62. What is the index of polytropic process?
(a) 1.10   (b) 1.15
(c) 1.20   (d) 1.25

490.   (d)
For polytropic process,

$$Q = W\left(\frac{\gamma - n}{\gamma - 1}\right)$$

$$0.62 = \left(\frac{1.66 - n}{1.66 - 1}\right)(\gamma = 1.66 \text{ for Helium})$$

$$n = 1.25$$

Q.491 An irreversible heat engine receives 1000 kJ of heat from a reservoir at 200°C and produces work and rejects heat to a reservoir at 30°C. The second law of efficiency is 80%. The amount of work produced by the engine is
(a) 287.5 kJ   (b) 307.5 kJ
(c) 297.5 kJ   (d) 317.5 kJ

491.   (a)

$$\eta_{\max} = 1 - \frac{T_L}{T_H} = 1 - \frac{303}{473} = 0.359$$

$$\eta_{II} = 0.80 = \frac{\text{Actual efficiency}}{\text{Maximum possible efficiency}}$$

$$\Rightarrow \qquad \eta_{\text{actual}} = 0.80 \times 0.359 = 0.2875$$

$$\eta_{actual} = \frac{\text{Work done}}{\text{Heat supplied}} = \frac{W}{1000}$$

$$\Rightarrow \qquad W = 0.2875 \times 1000 = 287.5 \text{ kJ}$$

Q.492 Consider the following statements:

1. Triple point is the point at which three states of matter can be in equilibrium.
2. Critical point is the state at which liquid and vapour phase are in equilibrium.
3. Helium does not have a triple point.

Which of these statements is/are correct ?

(a) 1 and 2   (b) 2 and 3

(c) 3 only   (d) 1, 2 and 3

492. **(d)**

When we cool helium to near absolute zero, it shows some strange behavior and converts into a Super-fluid, and has two different fluid phases. This point is called the Lambda point . But it never becomes a solid no matter how close we go to absolute zero.

Q.493 Consider the following statements regarding electrolux refrigerator:

1. A pump is used for the circulation of solution.
2. In an $NH_3 - H_2O$ system, H_2 is chosen as the third fluid because it is non-corrosive and insoluble in water.
3. Partial pressure of H_2 provides the pressure difference of NH_3 between the condenser and the evaporator.

The correct statements is/are

(a) 1 only   (b) 1 and 2

(c) 2 and 3   (d) all are correct

493. **(c)**

The circulation takes place due to density difference.

Q.494 In an ideal VCR system, the refrigerant exits the compressor as saturated vapour ($h = 720$ kJ/kg) and it is undercooled by 10°C at the exit of the condenser. Assuming the enthalpy at the inlet of compressor is 520 kJ/kg and enthalpy of saturated liquid at the condenser pressure is 141 kJ/kg. If the power required by the compressor is 5 kW, the tonnage of refrigeration is

(Take $(c_p)_l = 2.1$ kJ/kgK)

(a) 2.26   (b) 2.86

(c) 1.96   (d) 3.06

494. **(b)**

Given: h_1 = 520 kJ/kg; h_2 = 720 kJ/kg; $h_3 = h_a - (c_p)_l(\Delta T)_{undercool}$
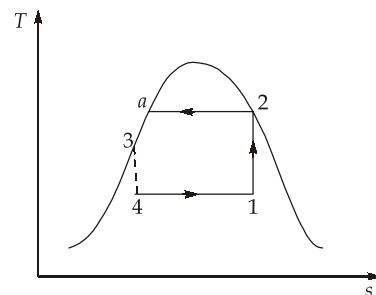
$$h_3 = 141 - 2.1 \times 10$$
$$h_3 = 120 \text{ kJ/kg}$$
$$h_4 = h_3 = 120 \text{ kJ/kg}$$
$$\text{COP} = \frac{h_1 - h_4}{h_2 - h_1} = \frac{520 - 120}{720 - 520} = 2$$
$$\text{COP} = \frac{3.5 \times TR}{P_{req.}}$$
$$2 = \frac{3.5 \times TR}{5}$$
$$TR = 2.8571$$

Q.495 Consider the following statements regarding the Bell Coleman cycle:

1. An isenthalpic expander may be installed in the cycle.
2. Performance of a closed cycle is better than an open cycle.
3. Coefficient of performance will decrease if the pressure ratio is increased.
4. The COP and refrigeration capacity depend only on the pressures.

The correct statements are

(a) 1 and 2
(b) 2 and 3
(c) 1 and 3
(d) 3 and 4

495. **(b)**

• For an ideal gas, the temperature remains constant in an isenthalpic expansion, so an expander turbine is used to get proper refrigeration.
• Any refrigerating fluid can be used in a closed cycle, so its performance is better.
• Since COP = $\dfrac{1}{r_p^{\frac{\gamma-1}{\gamma}} - 1}$, so if r_p increases, COP decrease.
• $RC = \dot{m}c_p(T_1 - T_4)$ which depends on the temperatures.

Q.496 Consider the following statements regarding leak detection of refrigerants:

1. Sulphur ribbon test is used to detect ammonia.
2. Soap bubble test is used for test is used for hydrocarbons.
3. Ammonia swab test is used for SO_2.
4. Halide torch test is used for hydrocarbons.

The correct statements are

(a) 1, 2 and 3
(b) 2, 3 and 4
(c) 1, 3 and 4
(d) 1, 2 and 4

496. **(a)**

Halide torch test is used for halogens.

Direction (Q.497 to Q.500): The following questions consists of two statements, one labelled as **Statement (I)** and the other labelled as **Statement (II)**. You have to examine these two statements carefully and select your answers to these items using the codes given below:

Codes:

(a) Both Statement (I) and Statement (II) are true and Statement (II) is the correct explanation of Statement (I).

(b) Both Statement (I) and Statement (II) are true but Statement (II) is not a correct explanation of Statement (I).

(c) Statement (I) is true but Statement (II) is false.

(d) Statement (I) is false but Statement (II) is true.

Q.497 Statement (I): Brazing is a joining process in which a filler metal is melted and distributed by capillary action between the faying surface of the metal parts being joined.

Statement (II): Melting of base metal as well as filler metals augments brazing process to take place.

497. (c)

There is no melting of the base metal occurs in brazing, only the filler metal melts in brazing.

Q.498 Statement (I): The GO/TO command is different from the GOTO command.

Statement (II): The GO/TO is used only for point to point motions and GOTO is used to initialize the sequence of contouring motions.

498. (c)

The GO/TO command is different from the GOTO command. GOTO is used only for point to point motions. The GO/TO is used to initialize the sequence of contouring motions.

Q.499 Statement (I): After completion of recrystallization, the strain-free grains will continue to grow if the metal specimen is left at the elevated temperature and that growth of grains is known as grain growth.

Statement (II): Grain growth is always preceded by recovery and recrystallization.

499. (c)

After recrystallization is complete, the strain-free grains will continue to grow if the metal specimen is left at the elevated temperature, this phenomenon is called grain growth. Grain growth does not need to be preceded by recovery and recrystallization. It may occur in all polycrystalline materials, metals and ceramics alike.

Q.500 Statement (I): All metals have unit cells with cubic symmetry.

Statement (II): Face centered cubic, body centered cubic and simple cubic structure are examples of cubic crystal system.

500. (d)

Not all metals have unit cells with cubic symmetry, some of the metals may have hexagonal close packed crystal structure. Some of the example of HCP crystal structure are Titanium, Zinc, Cadmium and Magnesium.

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