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CASTING & WELDING

MECHANICAL ENGINEERING

Date of Test : 07/08/2026

ANSWER KEY ➤

- | | | | | |
|--------|---------|---------|---------|---------|
| 1. (a) | 7. (a) | 13. (b) | 19. (b) | 25. (b) |
| 2. (b) | 8. (a) | 14. (c) | 20. (c) | 26. (a) |
| 3. (d) | 9. (a) | 15. (c) | 21. (b) | 27. (b) |
| 4. (b) | 10. (d) | 16. (b) | 22. (c) | 28. (a) |
| 5. (d) | 11. (a) | 17. (c) | 23. (c) | 29. (b) |
| 6. (d) | 12. (c) | 18. (d) | 24. (d) | 30. (b) |

DETAILED EXPLANATIONS

1. (a)

$$\begin{aligned}\text{Volume of weld} &= \frac{\pi}{4} d^2 l = \frac{\pi}{4} \times 1.5^2 \times 3.2 \times 1000 \\ &= 5652 \text{ mm}^3/\text{min}\end{aligned}$$

$$\text{Area of weld} = \frac{5652}{\text{Welding speed}} = \frac{5652}{150} = 37.68 \text{ mm}^2$$

2. (b)

Given: $P = 6 \text{ g/cm}^3$

$$T = 1 \text{ min } 50 \text{ s} = 1.833 \text{ min}$$

$$\text{Permeability number, } R = \frac{501.28}{P \times T} = \frac{501.28}{6 \times 1.833} = 45.579$$

4. (b)

Volume of casting, $V_c = 15 \times 15 \times 15 = 3375 \text{ cm}^3$

Minimum volume of the riser to be approximately three times of percentage of shrinkage volume of casting.

$$\begin{aligned}\text{Volume of riser, } V_r &= 3 \times 0.065 \times V_c \\ &= 3 \times 0.065 \times 3375 \\ &= 658.125 \text{ cm}^3\end{aligned}$$

5. (d)

Given: $I = 7000 \text{ A}$

$$t = 0.3 \text{ sec}$$

$$R = 250 \text{ micro-}\Omega = 0.25 \times 10^{-3} \Omega$$

$$\begin{aligned}\text{Heat generated, } Q &= I^2 R t = (7000)^2 \times 0.25 \times 10^{-3} \times 0.3 \text{ J} \\ &= 3675 \text{ J}\end{aligned}$$

6. (d)

Given: $d = 0.13 \text{ m}$ $h = 0.2 \text{ m}$

$$\rho_c = 1500 \text{ kg/m}^3, \quad \rho_z = 12000 \text{ kg/m}^3$$

$$\text{Net force} = g \cdot V (\rho_z - \rho_c) = 9.81 \times \frac{\pi}{4} \times (0.13)^2 \times 0.2 (10500) = 273.442 \text{ N}$$

8. (a)

$$\text{Volume of casting } V_c = \frac{\pi}{4} \times 120^2 \times 180 = 2035752$$

$$h_t = 180 + 50 = 230 \text{ mm}$$

$$A_c = A_{\min} = \text{Sprue base area} = 400 \text{ mm}^2$$

$$\text{Pouring time, } t = \frac{V_c}{A_c \times V_{\max}} = \frac{2035752}{400 \times \sqrt{2 \times 9810 \times 230}} = 2.395 \text{ sec.}$$

10. (d)

Surface area of cube = $6l^2$

Surface area of sphere = $4\pi r^2$

According to Chvorinov's relation

$$\text{Solidification time} \propto \left(\frac{\text{volume}}{\text{surface area}} \right)^2$$

as volume of cube and sphere are equal

$$\frac{t_c}{t_s} = \left(\frac{A_s}{A_c} \right)^2 = \left(\frac{4\pi r^2}{6l^2} \right)^2$$

$$\frac{t_c}{t_s} = \left(\frac{4\pi}{6} \right)^2 \left(\frac{r}{l} \right)^4$$

11. (a)

$$\text{Power, } P = VI$$

$$4V + I = 240$$

$$V = \frac{240 - I}{4}$$

$$P = \left(\frac{240 - I}{4} \right) \times I$$

$$\frac{dP}{dI} = \frac{d}{dI} \left(\frac{240I - I^2}{4} \right)$$

$$240 - 2I = 0$$

$$I = 120 \text{ Amp.}$$

∴ Voltage for maximum power,

$$4V + I = 240$$

$$4V = 240 - 120$$

$$V = 30 \text{ Volt}$$

12. (c)

$$\begin{aligned} Q_{\text{req.}} &= \frac{\pi}{4} d^2 h \times 12 = \frac{\pi}{4} \times 4^2 \times 1.8 \times 12 \\ &= 271.434 \text{ J} \end{aligned}$$

$$\begin{aligned} Q_{\text{Supplied}} &= I^2 R t = (10000)^2 \times 120 \times 10^{-6} \times 0.2 \\ &= 2400 \text{ J} \end{aligned}$$

$$\begin{aligned} Q_{\text{lost}} &= Q_{\text{Supplied}} - Q_{\text{Required}} \\ &= 2400 - 271.434 = 2128.56 \text{ J} \end{aligned}$$

13. (b)

$$\text{Solidification time, } t_c = K \left(\frac{V}{A} \right)^2$$

Where

V = Volume of casting

A = Surface area of casting

$$K = \text{Constant}$$

Given: For sphere and cube of given case, surface areas are same

i.e.

$$A_s = A_c$$

or

$$4\pi R^2 = 6a^2$$

$\Rightarrow$

$$\frac{R^2}{a^2} = \frac{6}{4\pi}$$

$$\text{Volume of sphere, } V_s = \frac{4}{3}\pi R^3$$

Where,

R = Radius of sphere

$$\text{Volume of cube, } V_c = a^3$$

Where,

a = Side of cube

$$\therefore \frac{\text{Solidification time of sphere}}{\text{Solidification time of cube}} = \frac{K.(V_s/A_s)^2}{K.(V_c/A_c)^2}$$

[Where $A_s = A_c$]

$$\begin{aligned} \frac{t_s}{t_c} &= \left(\frac{V_s}{V_c} \right)^2 = \left(\frac{\frac{4}{3}\pi R^3}{a^3} \right)^2 \\ &= \left(\frac{4\pi}{3} \right)^2 \times \left(\frac{R^2}{a^2} \right)^3 = \left(\frac{4\pi}{3} \right)^2 \times \left(\frac{6}{4\pi} \right)^3 = \frac{6}{\pi} \end{aligned}$$

14. (c)

$$\frac{V_t}{V_s} + \frac{I_t}{I_o} = 1$$

$$\frac{V_t}{60} + \frac{I_t}{600} = 1$$

$$V_t = 60 \left(1 - \frac{I_t}{600} \right)$$

$$P = V_t I_t = 60 I_t \left(1 - \frac{I_t}{600} \right)$$

$$\frac{dP}{dI_t} = 60 \left(1 - \frac{2I_t}{600} \right) = 0$$

$$I_t = \frac{600}{2} = 300 \text{ A}$$

$$V_t = 60 \times \frac{1}{2} = 30 \text{ V}$$

$$H_{\text{supplied}} = \frac{VI}{Av} \times \eta_h = \frac{300 \times 30}{20 \times v} \times 0.80 = \frac{360}{v}$$

$$H_{\text{supplied}} = 10$$

$$\eta_{\text{melting}} = \frac{H_{\text{required}}}{H_{\text{supplied}}} = \frac{10v}{360}$$

$\Rightarrow$

$$0.25 = \frac{10v}{360}$$

$\Rightarrow$

$$v = 9 \text{ mm/s}$$

15. (c)

Given:

$$h = 0.24 \text{ m}$$

$$A_1 = 2.2 \text{ m}^2$$

$$Q = 3 \text{ m}^3/\text{s}$$

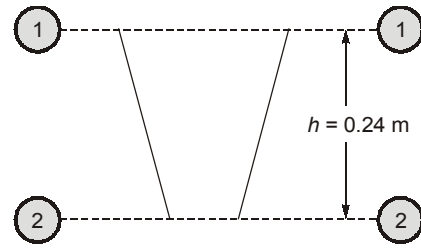
$$A_2 = ?$$

$$V_2 = \sqrt{2gh} = \sqrt{2 \times 9.81 \times 0.24}$$

$$= 2.169 \text{ m/s}$$

$$Q = A_2 V_2$$

$$A_2 = \frac{3}{2.169} = 1.38 \text{ m}^2$$



16. (b)

For a linear power source,

$$V = V_{oc} - \left(\frac{V_{oc}}{I_{sc}} \right) \times I = 40 - \frac{40}{400} I$$

$$\text{Power, } P = VI = (40 - 0.1I)I$$

$$\text{For maximum power, } \frac{dP}{dI} = 0$$

$$\Rightarrow 40 - 0.2I = 0$$

$$\Rightarrow I = 200 \text{ A}$$

$$\Rightarrow V = 20 \text{ V}$$

$$\text{Now, } P_{\max.} = VI = 200 \times 20 = 4000 \text{ W} = 4 \text{ kW}$$

17. (c)

Power source characteristics is linear, as given,

$$V = 20 + 6L$$

$$L_1 = 4 \text{ mm}$$

$$L_2 = 6 \text{ mm}$$

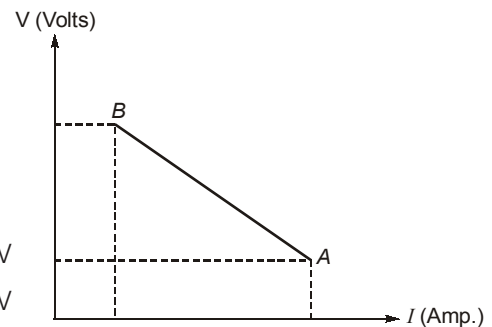
$$I_1 = 450 \text{ amp}$$

$$I_2 = 350 \text{ amp}$$

$$\text{Open circuit voltage, } V_{oc} = ?$$

$$\therefore V_1 = 20 + 6L = 20 + 6 \times 4 = 44 \text{ V}$$

$$V_2 = 20 + 6L = 20 + 6 \times 6 = 56 \text{ V}$$



$$\text{From the formula, } V = V_{oc} - \left(\frac{V_{oc}}{I_{sc}} \right) I$$

$$\text{At } (V_1, I_1), \quad 44 = V_{oc} - \left(\frac{V_{oc}}{I_{sc}} \right) 450 \quad \dots (i)$$

$$\text{At } (V_2, I_2), \quad 56 = V_{oc} - \left(\frac{V_{oc}}{I_{sc}} \right) 350 \quad \dots (ii)$$

After solving equations (i) and (ii), we get

$$V_{oc} = 98 \text{ V}$$

18. (d)

$$\text{Freezing ratio, } X = \frac{SA_{\text{casting}} / V_{\text{casting}}}{SA_{\text{riser}} / V_{\text{riser}}}$$

$$SA_{\text{casting}} = 2 \times 25 \times 25 + 4 \times 25 \times 5 = 1750 \text{ cm}^2$$

$$V_{\text{casting}} = 25 \times 25 \times 5 = 3125 \text{ cm}^3$$

$$V_{\text{riser}} = \frac{\pi D^3}{4} = 0.785 \times 12^3 = 1357.168 \text{ cm}^3$$

$$SA_{\text{riser}} = 2 \times \frac{\pi D^2}{4} + \pi D^2 = 1.5 \pi D^2 = 1.5 \times 3.14 \times 144 = 678.58 \text{ cm}^2$$

$$X = \frac{(1750/3125)}{(678.58/1357.168)} = 1.12$$

19. (b)

Given:

$$K = 2 \text{ s/mm}^2 = 2 \times 10^6 \text{ s/m}^2$$

$$h = 1000 \text{ mm} = 1 \text{ m}$$

$$d = 720 \text{ mm} = 0.72 \text{ m}$$

$$\begin{aligned} \text{Solidification time, } t &= K \left(\frac{\text{Volume}}{\text{Surface area}} \right)^2 = 2 \left(\frac{\frac{\pi}{4} d^2 h}{2 \left(\frac{\pi}{4} d^2 \right) + \pi d h} \right)^2 \\ &= 2 \left(\frac{\frac{\pi}{4} \times 0.72^2 \times 1}{2 \left(\frac{\pi}{4} \times 0.72^2 \right) + \pi \times 0.72 \times 1} \right)^2 = 2 \left(\frac{0.4072}{0.8143 + 2.2619} \right)^2 \\ &= 35044.22 \text{ sec} = 584.07 \text{ min} \end{aligned}$$

20. (c)

Given:

$$V = 30 \text{ V}$$

$$I = 250 \text{ A}$$

$$Q = 700 \text{ J/mm}$$

$$\eta = 0.8$$

$$\text{Speed, } C = ?$$

$$C = \frac{(\eta \cdot VI)}{Q} = \frac{0.8 \times 250 \times 30}{700}$$

$$= 8.57 \text{ mm/sec}$$

$$= 514.285 \text{ mm/min}$$

21. (b)

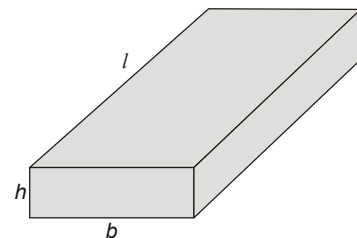
According to chronikov's rule,

$$t = k \left(\frac{V}{A} \right)^2$$

Now let l , b , h be the dimensions of cuboid,

$$V_i = l b h$$

$$A_i = 2[lb + bh + hl]$$



According to question, $V_f = (3l)(3b)(3h) = 3^3 V_i$
 $A_f = 2 \times 3^2 [lb + bh + hl]$
 $= 3^2 A_i$
 $t_i = k \left(\frac{V_i}{A_i} \right)^2$ $t_f = k \left(\frac{3^3 V_i}{3^2 A_i} \right)^2$
 $\frac{t_f}{t_i} = 9$
 $\frac{t_f}{t_i} - 1 = 9 - 1$
 $\left(\frac{t_f - t_i}{t_i} \right) \times 100 = 800\%$

22. (c)

Given: $\frac{d_1 + d_2}{d_1 - d_2} = 3$
 $d_1 + d_2 = 3d_1 - 3d_2$
 $2d_1 = 4d_2$
 $d_1 = 2d_2$
 $A_1 v_1 = A_2 v_2$
For no, aspiration, $\frac{A_2}{A_1} = \sqrt{\frac{h_c}{0.2 + h_c}}$
 $\frac{d_2^2}{d_1^2} = \sqrt{\frac{h_c}{0.2 + h_c}}$
 $\frac{d_2^2}{4d_2^2} = \frac{h_c}{0.2 + h_c}$ $(d_1 = 2d_2)$
 $0.2 + h_c = 16h_c$
 $h_c = \frac{0.2}{15} = 0.01333 \text{ m} = 1.33 \text{ cm}$

23. (c)

Pouring time, $t = 2.3\sqrt{W}$ sec
 $t = 2.3\sqrt{25} = 11.5 \text{ sec}$
choke area = area of sprue base (1 : 2 : 2 - unpressurised casting)
 $A = \frac{W}{c p t \sqrt{2gh}} = \frac{25}{0.89 \times 8.0 \times 10^{-3} \times 11.5 \times \sqrt{2 \times 9.81 \times 20 \times 100}}$
where c is the flow efficiency factor
 $= 1.54 \text{ cm}^2$
Sprue area at the top = $2A = 2 \times 1.54 = 3.08 \text{ cm}^2$
diameter of sprue at the top = $\sqrt{3.08 \times \frac{4}{\pi}} = 1.98 \text{ cm}$

24. (d)

Let welding current = I So, Heat generated = $VI = 40I$ J/s

$$\begin{aligned} \text{Heat required for welding,} &= \frac{\pi d^2}{4} \times R \times \rho \times (L + c_p \times \Delta T) \\ &= \frac{\pi}{4} \times 1.5^2 \times 10^{-6} \times \frac{14}{60} \times 8000 (265.6 \times 10^3 + 600 \times (1580 - 30)) = 3943.89 \text{ J/s} \end{aligned}$$

$$\begin{aligned} \text{Now, heat available for melting} &= \eta_{\text{electric}} \times \text{Heat generated} \\ &= 0.65 \times 40 \times I = 26I \text{ J/s} \end{aligned}$$

$$\begin{aligned} \text{Heat required for welding} &= \eta_{\text{melting}} \times \text{Heat available for melting} \\ 3943.89 &= 0.4 \times 26I \end{aligned}$$

$$I = \frac{3943.89}{10.4} = 379.22 \text{ Amp.} = 380 \text{ Amp.}$$

25. (b)

Power in this arc welding operation, $P = VI$.

$$P = 300 \times 20 = 6000 \text{ W}$$

The rate of heat used for welding is

$$\begin{aligned} &= (\text{melting factor} \times \text{heat transfer factor} \times P) \\ &= 0.5 \times 0.7 \times 6000 = 2100 \text{ Watt} \end{aligned}$$

The volume rate of metal welded

$$= \frac{2100 \text{ Joule/sec}}{10 \text{ Joule/mm}^3} = 210 \text{ mm}^3/\text{sec}$$

26. (a)

Given

$$\begin{aligned} V_C &= \text{Volume of casting} = 20 \times 20 \times 5 \text{ cm}^3 \\ &= 2000 \text{ cm}^3 \end{aligned}$$

for side riser

$$h = d$$

$$\left(\frac{A}{V} \right)_r = \frac{6}{d}$$

Step - 1 :

$$V_r = \text{Volume of riser} = 3 \times \text{times the percentage shrinkage volume} \times V_C$$

$$\text{linear shrinkage} = 1\%$$

$$= \text{final dimension} = (1 - 0.01) \times a$$

$$\Rightarrow \% \text{volume shrinkage} = (1 - 0.99^3) \times 100\% = 2.97\%$$

$$\Rightarrow \text{Volume shrinkage} = 2000 \times \frac{2.97}{100} = 59.402 \text{ cm}^3$$

$$\Rightarrow V_r = 3 \times 59.402 = 178.206 \text{ cm}^3 = \frac{\pi}{4} d^3$$

$$\Rightarrow d = 6.1 \text{ cm}$$

$$\begin{aligned} \Rightarrow \left(\frac{A}{V} \right)_r &= \frac{6}{d} = 0.983 \text{ cm}^{-1}, \text{ but for casting, } \left(\frac{A}{V} \right)_c = \frac{(20 \times 20 + 2 \times 20 \times 5) \times 2}{2000} \\ &= 0.6 \text{ cm}^{-1} \end{aligned}$$

$$\Rightarrow \left(\frac{A}{V} \right)_r \leq \left(\frac{A}{V} \right)_c \quad \text{at critical condition}$$

$$\Rightarrow \left(\frac{A}{V} \right)_r = \left(\frac{A}{V} \right)_c$$

$$\Rightarrow \frac{6}{d} = 0.6$$

$$\Rightarrow d = 10 \text{ cm}$$

27. (b)

for steel rectangular plate

$$\text{volume, } V_1 = 7.5 \times 12.5 \times 2.0 = 187.5 \text{ cm}^3$$

$$\begin{aligned} \text{surface area, } A_1 &= 2(7.5 \times 12.5 + 12.5 \times 2.0 + 2.0 \times 7.5) \\ &= 267.5 \text{ cm}^2 \end{aligned}$$

$$t_{s1} = 1.6 \text{ min}$$

as we know

$$\text{chvorinov's rate, } t_{s1} = K \left(\frac{V}{A} \right)_1^2$$

$$\text{mould constant, } K = \frac{1.6}{\left(\frac{187.5}{267.5} \right)^2}$$

$$\text{mould constant, } K = 3.26 \text{ min/cm}^2$$

for cylindrical riser design

$$\text{Since } \frac{D}{H} = 1.0 \text{ it is the condition for side riser}$$

$$V_2 = \frac{\pi D^3}{4}$$

$$A_2 = \pi D^2 + 2\pi D^2/4 = 1.5\pi D^2$$

$$\left(\frac{V}{A} \right)_2 = \left(\frac{D}{6} \right)$$

from chvorinov's equation

$$t_{s2} = K \left(\frac{V}{A} \right)_2^2$$

$$3.0 = 3.26 \left(\frac{D}{6} \right)^2$$

$$D = 5.755 \text{ cm}$$

$$\frac{D}{H} = 1$$

$$\text{So, } H = 5.755 \text{ cm}$$

28. (a)

$$\text{Energy input per unit length} = \frac{VI}{v} \times \eta_{HT} = \frac{500 \times 25}{5} \times 0.75 = 1875 \text{ J/mm}$$

29. (b)

$$t_s = \left(\frac{V}{A} \right)^2$$

$$\left(\frac{V}{A} \right)_{\text{cube}} = \frac{a^3}{6a^2} = \frac{a}{6}$$

For cube,

$$V = a^3 = 27$$

$$a = 3 \text{ cm}$$

$$\left(\frac{V}{A} \right)_{\text{cube}} = \frac{3}{6} = 0.5$$

For cylinder,

$$\frac{V}{A} = \frac{\pi R^2 h}{2\pi R^2 + 2\pi R h} = \frac{Rh}{2R + 2h} = \frac{1 \times 6}{2 + 12} = \frac{6}{14}$$

$$\frac{(t)_{\text{cylinder}}}{(t)_{\text{cube}}} = \left(\frac{6}{14 \times 0.5} \right)^2 = 0.7347$$

$$(t)_{\text{cylinder}} = 0.7347 \times 180$$

$$= 132.246 \text{ sec} = 2.2 \text{ min}$$

30. (b)

$$\text{Solidification time, } t_s = k \left(\frac{V}{A} \right)^2$$

$$t_s \propto (\text{Thickness})^2$$

$$\frac{4}{2} = \left(\frac{t_2}{3} \right)^2$$

$$t_2 = 4.24 \text{ mm} \approx 4.2 \text{ mm}$$

