

Thermal Properties of Matter — NEET Physics PYQ (2005-2021)

Class 11 Physics · 28 real NEET & AIPMT questions, year-tagged · answers checked by RankUp

NEET 2021

1. A cup of coffee cools from 90°C to 80°C in t minutes, when the room temperature is 20°C . The time taken by a similar cup of coffee to cool from 80°C to 60°C at a room temperature same at 20°C is :

- (A) $(13/10) t$
- (B) $(13/5) t$
- (C) $(10/13) t$
- (D) $(5/13) t$

NEET 2020 · Q174

2. The quantities of heat required to raise the temperature of two solid copper spheres of radii r_1 and r_2 ($r_1 = 1.5 r_2$) through 1 K are in the ratio :

- (A) $27/8$
- (B) $9/4$
- (C) $3/2$
- (D) $5/3$

NEET 2019 · Q14

3. A copper rod of 88 cm and an aluminium rod of unknown length have their increase in length independent of increase in temperature. The length of aluminium rod is: ($\alpha_{\text{Cu}} = 1.7 \times 10^{-5}\text{ K}^{-1}$ and $\alpha_{\text{Al}} = 2.2 \times 10^{-5}\text{ K}^{-1}$)

- (A) 6.8 cm
- (B) 113.9 cm
- (C) 88 cm
- (D) 68 cm

NEET 2019 · Q20

4. The unit of thermal conductivity is:

- (A) J m K^{-1}
- (B) $\text{J m}^{-1}\text{ K}^{-1}$
- (C) W m K^{-1}
- (D) $\text{W m}^{-1}\text{ K}^{-1}$

NEET 2018 · Q43

5. The power radiated by a black body is P and it radiates maximum energy at wavelength, λ_0 . If the temperature of the black body is now changed so that it radiates maximum energy at wavelength $(3/4)\lambda_0$, the power radiated by it becomes nP . The value of n is

- (A) $256/81$
- (B) $4/3$
- (C) $3/4$
- (D) $81/256$

NEET 2017 · Q136

6. A spherical black body with a radius of 12 cm radiates 450 watt power at 500 K . If the radius were halved and the temperature doubled, the power radiated in watt would be:

- (A) 225
- (B) 450
- (C) 1000
- (D) 1800

7. In a certain planetary system, it is observed that one of the celestial bodies having a surface temperature of 200 K, emits radiation of maximum intensity near the wavelength $12\text{ }\mu\text{m}$. The surface temperature of a nearby star which emits light of maximum intensity at a wavelength $\lambda = 4800\text{ }\text{\AA}$, is:

- (A) 5000 K
- (B) 2500 K
- (C) 10000 K
- (D) 7500 K

8. Two identical bodies are made of a material for which the heat capacity increases with temperature. One of these is at $100\text{ }^{\circ}\text{C}$, while the other one is at $0\text{ }^{\circ}\text{C}$. If the two bodies are brought into contact, then, assuming no heat loss, the final common temperature is

- (A) $50\text{ }^{\circ}\text{C}$
- (B) more than $50\text{ }^{\circ}\text{C}$
- (C) less than $50\text{ }^{\circ}\text{C}$ but greater than $0\text{ }^{\circ}\text{C}$
- (D) $0\text{ }^{\circ}\text{C}$

9. A body cools from a temperature $3T$ to $2T$ in 10 minutes. The room temperature is T . Assume that Newton's law of cooling is applicable. The temperature of the body at the end of next 10 minutes will be

- (A) $7T/4$
- (B) $3T/2$
- (C) $4T/3$
- (D) T

10. A black body is at a temperature of 5760 K. The energy of radiation emitted by the body at wavelength 250 nm is U_1 , at wavelength 500 nm is U_2 and that at 1000 nm is U_3 . Wien's constant, $b = 2.88 \times 10^6\text{ nmK}$. Which of the following is correct?

- (A) $U_1 = 0$
- (B) $U_3 = 0$
- (C) $U_1 > U_2$
- (D) $U_2 > U_1$

11. Coefficient of linear expansion of brass and steel rods are α_1 and α_2 . Lengths of brass and steel rods are l_1 and l_2 respectively. If $(l_2 - l_1)$ is maintained same at all temperatures, which one of the following relations holds good?

- (A) $\alpha_1 l_2 = \alpha_2 l_1$
- (B) $\alpha_1 l_2^2 = \alpha_2 l_1^2$
- (C) $\alpha_1^2 l_2 = \alpha_2^2 l_1$
- (D) $\alpha_1 l_1 = \alpha_2 l_2$

12. A piece of ice falls from a height h so that it melts completely. Only one-quarter of the heat produced is absorbed by the ice and all energy of ice gets converted into heat during its fall. The value of h is: [Latent heat of ice is $3.4 \times 10^5\text{ J/kg}$ and $g = 10\text{ N/kg}$]

- (A) 34 km
- (B) 544 km
- (C) 136 km
- (D) 68 km

AIPMT 2015

13. The two ends of a metal rod are maintained at temperatures 100°C and 110°C . The rate of heat flow in the rod is found to be 4.0 J/s . If the ends are maintained at temperatures 200°C and 210°C , the rate of heat flow will be:

- (A) 4.0 J/s
- (B) 44.0 J/s
- (C) 16.8 J/s
- (D) 8.0 J/s

AIPMT 2015

14. On observing light from three different stars P, Q and R, it was found that intensity of violet colour is maximum in the spectrum of P, the intensity of green colour is maximum in the spectrum of R and the intensity of red colour is maximum in the spectrum of Q. If T_P , T_Q and T_R are the respective absolute temperatures of P, Q and R, then it can be concluded from the above observations that:

- (A) $T_P < T_Q < T_R$
- (B) $T_P > T_Q > T_R$
- (C) $T_P > T_R > T_Q$
- (D) $T_P < T_R < T_Q$

AIPMT 2014

15. Certain quantity of water cools from 70°C to 60°C in the first 5 minutes and to 54°C in the next 5 minutes. The temperature of the surroundings is:

- (A) 20°C
- (B) 42°C
- (C) 10°C
- (D) 45°C

AIPMT 2014

16. Steam at 100°C is passed into 20 g of water at 10°C . When water acquires a temperature of 80°C , the mass of water present will be: [Take specific heat of water = $1 \text{ cal g}^{-1} \text{ }^{\circ}\text{C}^{-1}$ and latent heat of steam = 540 cal g^{-1}]

- (A) 31.5 g
- (B) 42.5 g
- (C) 22.5 g
- (D) 24 g

NEET 2013

17. A piece of iron is heated in a flame. It first becomes dull red then becomes reddish yellow and finally turns to white hot. The correct explanation for the above observation is possible by using -

- (A) Stefan's law
- (B) Wien's displacement law
- (C) Kirchhoff's law
- (D) Newton's law of cooling

AIPMT 2012 Mains

18. A slab of stone of area 0.36 m^2 and thickness 0.1 m is exposed on the lower surface to steam at 100°C . A block of ice at 0°C rests on the upper surface of the slab. In one hour 4.8 kg of ice is melted. The thermal conductivity of slab is (Given latent heat of fusion of ice = $3.36 \times 10^5 \text{ J kg}^{-1}$)

- (A) $1.24 \text{ J/m/s/}^{\circ}\text{C}$
- (B) $1.29 \text{ J/m/s/}^{\circ}\text{C}$
- (C) $2.05 \text{ J/m/s/}^{\circ}\text{C}$
- (D) $1.02 \text{ J/m/s/}^{\circ}\text{C}$

19. If the radius of a star is R and it acts as a black body, what would be the temperature of the star, in which the rate of energy production is Q ? (σ stands for Stefan's constant)

- (A) $(Q/(4\pi R^2\sigma))^{1/4}$
- (B) $Q/(4\pi R^2\sigma)$
- (C) $(Q/(4\pi R^2\sigma))^{-1/2}$
- (D) $(4\pi R^2Q/\sigma)^{1/4}$

20. A cylindrical metallic rod in thermal contact with two reservoirs of heat at its two ends conducts an amount of heat Q in time t . The metallic rod is melted and the material is formed into a rod of half the radius of the original rod. What is the amount of heat conducted by the new rod, when placed in thermal contact with the two reservoirs in time t ?

- (A) $Q/2$
- (B) $Q/4$
- (C) $Q/16$
- (D) $2Q$

21. The total radiant energy per unit area, normal to the direction of incidence, received at a distance R from the centre of a star of radius r , whose outer surface radiates as a black body at a temperature T K is given by (where σ is Stefan's constant)

- (A) $4\pi\sigma r^2T^4/R^2$
- (B) $\sigma r^2T^4/R^2$
- (C) $\sigma r^2T^4/(4\pi r^2)$
- (D) $\sigma r^4T^4/r^4$

22. The two ends of a rod of length L and a uniform cross-sectional area A are kept at two temperatures T_1 and T_2 ($T_1 > T_2$). The rate of heat transfer, dQ/dt , through the rod in a steady state is given by:

- (A) $dQ/dt = k(T_1 - T_2)/(LA)$
- (B) $dQ/dt = kLA(T_1 - T_2)$
- (C) $dQ/dt = kA(T_1 - T_2)/L$
- (D) $dQ/dt = kL(T_1 - T_2)/A$

23. A black body at 227°C radiates heat at the rate of $7 \text{ cal/cm}^2 \text{ s}$. At a temperature of 727°C , the rate of heat radiated in the same units will be:

- (A) 50
- (B) 112
- (C) 80
- (D) 60

24. On a new scale of temperature (which is linear) and called the W scale, the freezing and boiling points of water are $39^\circ W$ and $239^\circ W$ respectively. What will be the temperature on the new scale, corresponding to a temperature of 39°C on the Celsius scale?

- (A) $139^\circ W$
- (B) $78^\circ W$
- (C) $117^\circ W$
- (D) $200^\circ W$

25. A black body is at 727° C. It emits energy at a rate which is proportional to

- (A) $(1000)^4$
- (B) $(1000)^2$
- (C) $(727)^4$
- (D) $(727)^2$

26. Assuming the sun to have a spherical outer surface of radius r , radiating like a black body at temperature $t^\circ\text{C}$, the power received by a unit surface, (normal to the incident rays) at a distance R from the centre of the sun is (where σ is the Stefan's constant)

- (A) $r^2\sigma(t + 273)^4/(4\pi R^2)$
- (B) $16\pi^2 r^2\sigma t^4/R^2$
- (C) $r^2\sigma(t + 273)^4/R^2$
- (D) $4\pi r^2\sigma t^4/R^2$

27. A black body at 1227°C emits radiations with maximum intensity at a wavelength of 5000 Å. If the temperature of the body is increased by 1000°C, the maximum intensity will be observed at :

- (A) 7500 Å
- (B) 1500 Å
- (C) 6000 Å
- (D) 3000 Å

28. Which of the following circular rods, (given radius r and length l) each made of the same material and whose ends are maintained at the same temperature will conduct most heat ?

- (A) $r = 2r_0; l = 2l_0$
- (B) $r = 2r_0; l = l_0$
- (C) $r = r_0; l = l_0$
- (D) $r = r_0; l = 2l_0$

Answer key and explanations

1. Answer: (B) (13/5) t

Using the average form of Newton's law of cooling: $10/t = k(85 - 20) = 65k$ and $20/t' = k(70 - 20) = 50k$. Dividing, $t' = (20 \times 65)/(10 \times 50)$ $t = 2.6t = (13/5)t$. The inverse ratio $(5/13)t$ would wrongly suggest the larger, cooler drop takes less time.

2. Answer: (A) 27/8

$Q = mc\Delta T$ with the same c and ΔT , and $m \propto \text{volume} \propto r^3$, so $Q_1/Q_2 = (1.5)^3 = 27/8$. Using surface area (r^2) instead of volume would give 9/4.

3. Answer: (D) 68 cm

Equal expansions require $L_{\text{Cu}} \alpha_{\text{Cu}} = L_{\text{Al}} \alpha_{\text{Al}}$, so $L_{\text{Al}} = 88 \times 1.7/2.2 = 68$ cm. 113.9 cm comes from inverting the ratio of expansion coefficients.

4. Answer: (D) $\text{W m}^{-1} \text{K}^{-1}$

From $H = KA(\Delta T)/L$, $K = HL/(A\Delta T)$, giving $\text{W} \cdot \text{m}/(\text{m}^2 \cdot \text{K}) = \text{W m}^{-1} \text{K}^{-1}$. $\text{J m}^{-1} \text{K}^{-1}$ misses the per-second (rate) part of heat flow.

5. Answer: (A) 256/81

Wien's law $\lambda_m T = \text{constant}$ gives $T' = (4/3)T$. By Stefan's law $P \propto T^4$, so $n = (4/3)^4 = 256/81$. The inverse 81/256 would correspond to cooling, not heating.

6. Answer: (D) 1800

By the Stefan-Boltzmann law $P = \sigma(4\pi r^2)T^4$, so $P \propto r^2 T^4$. Halving r multiplies P by 1/4 and doubling T multiplies it by 16, a net factor of 4: $450 \times 4 = 1800$ W. Keeping only the radius change would give the trap value of about 112 W, and assuming the effects cancel gives 450 W.

7. Answer: (A) 5000 K

By Wien's law $\lambda_{\text{max}} T$ is constant: $12 \times 10^{-6} \text{ m} \times 200 \text{ K} = 2.4 \times 10^{-3} \text{ m K}$. For the star $T = 2.4 \times 10^{-3} / 4800 \times 10^{-10} = 5000 \text{ K}$. Getting 10000 K means 4800 Å was taken as $2.4 \times 10^{-7} \text{ m}$, a unit slip.

8. Answer: (B) more than 50 °C

The hot body has the larger heat capacity, so it gives out more heat per degree of cooling than the cold body absorbs per degree of warming. To balance heat lost and gained, the hot body cools through fewer degrees than the cold one warms, so the final temperature lies above 50 °C. Exactly 50 °C would need a constant heat capacity.

9. Answer: (B) 3T/2

With the average form: $(3T - 2T)/10 = k(2.5T - T)$ gives $k = 1/15$ per minute; then $(2T - \theta)/10 = k((2T + \theta)/2 - T)$ gives $6T - 3\theta = \theta$, so $\theta = 3T/2$. The exponential form agrees: the excess over the room halves from $2T$ to T , so it becomes $T/2$ and $\theta = 1.5T$. Assuming equal fall per interval would wrongly give T .

10. Answer: (D) $U_2 > U_1$

By Wien's law $\lambda_{\text{max}} = b/T = 2.88 \times 10^6/5760 = 500 \text{ nm}$, so emission peaks at 500 nm and U_2 is the largest; hence $U_2 > U_1$. A black body emits at all wavelengths, so neither U_1 nor U_3 is zero.

11. Answer: (D) $\alpha_1 l_1 = \alpha_2 l_2$

For the difference to stay constant, both rods must expand by the same amount for any temperature change: $l_1 \alpha_1 \Delta T = l_2 \alpha_2 \Delta T$, so $\alpha_1 l_1 = \alpha_2 l_2$. Swapping the lengths ($\alpha_1 l_2 = \alpha_2 l_1$) is the common trap.

12. Answer: (C) 136 km

$(1/4)mgh = mL$, so $h = 4L/g = 4 \times 3.4 \times 10^5/10 = 1.36 \times 10^5 \text{ m} = 136 \text{ km}$. Ignoring the one-quarter factor gives 34 km.

13. Answer: (A) 4.0 J/s

The conduction rate is $kA\Delta T/L$ and depends on the temperature difference, not the actual temperatures. ΔT is 10 °C in both cases, so the rate stays 4.0 J/s (ignoring change of k with temperature).

14. Answer: (C) $T_P > T_R > T_Q$

By Wien's displacement law $\lambda_{\text{max}} T = \text{constant}$, so a shorter peak wavelength means a hotter star. $\lambda_{\text{violet}} < \lambda_{\text{green}} < \lambda_{\text{red}}$, hence $T_P > T_R > T_Q$.

15. Answer: (D) 45°C

Using Newton's law with average temperatures: $10/5 = k(65 - T_0)$ and $6/5 = k(57 - T_0)$. Dividing, $5/3 = (65 - T_0)/(57 - T_0)$, so $T_0 = 45^\circ\text{C}$.

16. Answer: (C) 22.5 g

Heat from steam condensing and cooling to 80°C: $m(540 + 20) = 560m$. Heat gained by water: $20 \times 1 \times 70 = 1400 \text{ cal}$, so $m = 2.5 \text{ g}$. Total water = $20 + 2.5 = 22.5 \text{ g}$.

17. Answer: (B) Wien's displacement law

Wien's displacement law, $\lambda_m T = \text{constant}$, says that the wavelength of maximum emission shifts to shorter values as temperature rises, so the colour changes from red towards yellow and white. Stefan's law gives only the total power radiated, not the colour.

18. Answer: (A) 1.24 J/m/s/°C

Heat rate = $mL/t = (4.8 \times 3.36 \times 10^5)/3600 = 448 \text{ W}$. Setting $KA\Delta T/d = 448$ gives $K \times 0.36 \times 100/0.1 = 360K = 448$, so $K \approx 1.24 \text{ J m}^{-1} \text{ s}^{-1} \text{ }^\circ\text{C}^{-1}$.

19. Answer: (A) $(Q/(4\pi R^2 \sigma))^{1/4}$

For a black body, power radiated = $\sigma T^4 \times \text{area} = 4\pi R^2 \sigma T^4$. In steady state this equals the energy production rate Q , so $T = (Q/(4\pi R^2 \sigma))^{1/4}$. The expression without the fourth root gives T^4 , not T .

20. Answer: (C) Q/16

Volume is fixed: halving the radius makes the area $A/4$, so the length becomes $4L$. Heat flow $\propto A/L$, so it becomes $1/4 \div 4 = 1/16$ of the original: $Q/16$. Taking only the area change gives $Q/4$.

21. Answer: (B) $\sigma r^2 T^4 / R^2$

The star emits $\sigma T^4 \times 4\pi r^2$ in total. At distance R this spreads over a sphere of area $4\pi R^2$, so energy per unit area per second = $\sigma T^4 \cdot 4\pi r^2 / (4\pi R^2) = \sigma r^2 T^4 / R^2$. Keeping the 4π in the numerator forgets to divide by the full sphere area.

22. Answer: (C) $dQ/dt = kA(T_1 - T_2)/L$

Fourier's law for steady conduction gives $dQ/dt = kA(T_1 - T_2)/L$: the heat current grows with area and temperature difference and falls with length. Forms with L in the numerator or A in the denominator have the wrong dependence.

23. Answer: (B) 112

Stefan's law: $E \propto T^4$ with absolute temperatures. $227^\circ\text{C} = 500\text{ K}$ and $727^\circ\text{C} = 1000\text{ K}$, so E rises by $(1000/500)^4 = 16$: $7 \times 16 = 112\text{ cal/cm}^2\text{ s}$. Using Celsius temperatures directly gives wrong ratios.

24. Answer: (C) 117° W

For a linear scale, $(W - 39)/(239 - 39) = (C - 0)/(100 - 0)$. With $C = 39$: $W = 39 + 200 \times 0.39 = 39 + 78 = 117^\circ\text{ W}$. 78° W forgets to add the offset of the freezing point.

25. Answer: (A) $(1000)^4$

By Stefan's law the emitted power $\propto T^4$ with T in kelvin: $727 + 273 = 1000\text{ K}$, so rate $\propto (1000)^4$. Using 727 forgets to convert from Celsius.

26. Answer: (C) $r^2\sigma(t + 273)^4/R^2$

The sun radiates $P = 4\pi r^2\sigma(t + 273)^4$. At distance R this spreads over $4\pi R^2$, giving $r^2\sigma(t + 273)^4/R^2$ per unit area. Options using t^4 forget to convert to kelvin, and dividing by an extra 4π is wrong.

27. Answer: (D) $3000\text{ \AA}$

By Wien's law $\lambda_m T$ is constant. $T_1 = 1227 + 273 = 1500\text{ K}$ and $T_2 = 2500\text{ K}$, so $\lambda_2 = 5000 \times 1500/2500 = 3000\text{ \AA}$. Using Celsius temperatures (1227 and 2227) would give a wrong ratio; the peak must shift to a shorter wavelength as the body gets hotter.

28. Answer: (B) $r = 2r_0$; $I = I_0$

Heat current $H = kA\Delta T/l \propto r^2/l$. For $r = 2r_0$, $I = I_0$ this is $4r_0^2/I_0$, the largest; $r = 2r_0$, $I = 2I_0$ gives only $2r_0^2/I_0$.

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