Solutions

Question 18

Lower fixed point: 0 °C
- freezing point of water
Upper fixed point: 100 °C
Boiling point of water

Question 19

Convert to kelvin
0 °C = 273 K
100 °C = 373 K

Question 20

295 K

Question 21

673 °C

Question 22

246 K

Question 23

-223 °C

Question 24

727 °C

Question 25

352 K

Question 26

57 K

Question 27

70 °C

Question 28

-100 °C, 200 K, 0 °C, 300 K, 30 °C, the boiling point of water

Question 29

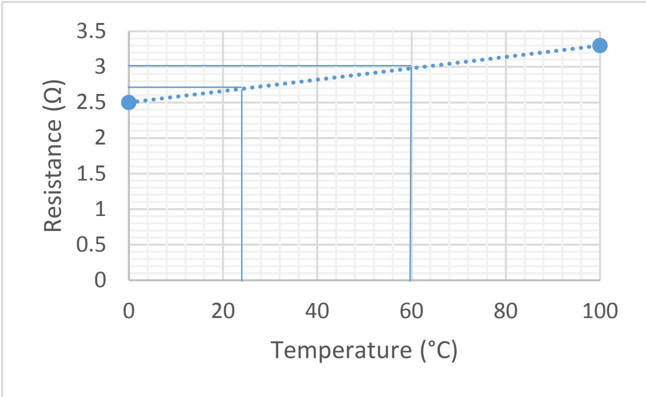
Conventionally it is considered that there are no negatives in the kelvin scale.
∴ B

If you want to stretch your brain you might want to visit:
https://phys.org/news/2013-01-atoms-negative-absolute-temperature-hottest.html

Question 30

Expansion/resistance etc. varying linearly with temperature

Question 31



∴ ~22 °C and ~60 °C respectively
Or use arithmetic,

$$\text{gradient} = \frac{3.3 - 2.5}{100} = 0.008 \text{ ohms deg}^{-1}$$

(i) ∴ $3.0 = 2.5 + 0.008 \times \Delta T$
∴ $\Delta T = 62.5$ °C

(ii) ∴ $2.7 = 2.5 + 0.008 \times \Delta T$
∴ $\Delta T = 25$ °C

Question 32

The lowest possible temperature. When the particles have zero thermal movement.

Question 33

Kinetic energy of particles decreases with lowered temperature

Question 34

23 °C

Question 35

Joule (J)

Question 36

(A) They are gaining translational kinetic energy

Question 37

Molecules in a solid are held tightly together in a set array. They cannot move around, only vibrate. Solids hold a particular shape and volume.

Question 38

Molecules in a liquid are in constant motion relative to each other. Forces of attraction cause the particles to occupy a definite volume, but they hold no particular shape.

Question 39

Molecules in a gas are almost completely free of each other's influence. They hold no particular shape or volume.

Question 40

Size increases as pressure decreases, so the bubble grows as it rises

Question 41

Temperature increases as pressure increases.

Question 42

Increasing pressure increases the temperature at which gas liquefies, but as pressure increases so does the temperature of the gas. Therefore the temperature needs to be reduced past the liquefication point. For storage, it is easier to use high pressure.

Question 43

$$\Delta U = \Delta W + \Delta Q$$

$$\Delta U = 40 + 15$$

$$= 55\ \text{kJ}$$

Question 44

$$\Delta U = \Delta W + \Delta Q$$

$$\Delta U = 30 + 100$$

$$= 130\ \text{J}$$

Question 45

$$\Delta U = \Delta W + \Delta Q$$

$$230 = -320 + \Delta W$$

$$\Delta W = 230 + 320$$

$$= 550\ \text{J}$$

Question 46

No, not on a universal scale. You can decrease entropy in a system, but only by increasing entropy in another system.

Question 47

$$Q = mc\Delta T$$

$$= 5 \times 377 \times 50$$

$$= 94250\ \text{J}$$

$$= 94.25\ \text{kJ}$$

Question 48

(C) The metal with the greatest specific heat will undergo the smallest change in temperature.

Question 49

$$Q = mc\Delta T$$

$$131040 = 4 \times 4200 \times \Delta T$$

$$\Delta T = \frac{131040}{4 \times 4200}$$

$$= 7.8$$

$$T = 10 + 7.8$$

$$= 17.8\ °C$$

Question 50

$$Q = mc\Delta T$$

$$= 1 \times 4200 \times 34$$

$$= 142\,800\ J$$

$$= 142.8\ kJ$$

(i) = (ii) because energy is conserved.

Question 51

$$Q = mc\Delta T$$

$$4560 = 1.5 \times c \times 5$$

$$c = \frac{4560}{1.5 \times 5}$$

$$= 608\ J/kg/K$$

The material may be glass

Question 52

$$Q = mc\Delta T$$

$$= 5 \times 4200 \times 3$$

$$= 63\,000\ J$$

$$= 63\ kJ$$

Question 53

$$Q = mc\Delta T$$

$$= .865 \times 880 \times 65$$

$$= 49\,478\ J$$

$$= 49\ kJ$$

Question 54

$$Q = mc\Delta T$$

$$Q_A = 1.1 \times 880(92 - T)$$

$$Q_W = 0.5 \times 4200(T - 12)$$

$$Q_A = Q_W$$

$$\backslash\ 968(92 - T) = 2100(T - 12)$$

$$89\,056 - 968T = 2100T - 25200$$

$$114\,256 = 3068T$$

$$T = \frac{114256}{3068}$$

$$= 37\ °C$$

Question 55

$$Q = mc\Delta T$$

$$Q_I = 60 \times 440(120 - T)$$

$$Q_W = 200 \times 4200(T - 20)$$

$$Q_I = Q_W$$

$$\therefore 26\,400(120 - T) = 840\,000(T - 20)$$

$$\therefore 3\,168\,000 - 26\,400T = 840\,000T - 16\,800\,000$$

$$\therefore 1.9968 \times 10^7 = 8.664 \times 10^5 T$$

$$\therefore T = \frac{1.9968 \times 10^7}{8.664 \times 10^5}$$

$$= 23\ °C$$

Question 56

$Q = mc\Delta T$

$0.2 \times 4200 \times (90 - T) = 0.5 \times 4200 \times (T - 16)$

$18 - 0.2T = 0.5T - 8$

$26 = 0.7T$

$T = \dfrac{2.6}{0.7}$

$= 37\ °C$

Question 57

$Q = mc\Delta T$

$0.1 \times 4200 \times (95 - T) = 0.5 \times 842 \times (T - 25)$

$39\,900 - 420T = 421T - 10\,525$

$50\,425 = 841T$

$T = \dfrac{50\,425}{841}$

$= 59.958$

$= 60\ °C$

Question 58

$Q = ML$

$= 4 \times 3.35 \times 10^5$

$= 1.34 \times 10^6\ J$

Question 59

$Q = ML$

$= 0.2 \times 2.3 \times 10^6$

$= 4.6 \times 10^5\ J$

Question 60

$Q = mc\Delta T + ml_v$

$\therefore\ Q = 4 \times 4200 \times 90 + 4 \times 2.3 \times 10^6$

$\therefore\ Q = 1\,512\,000 + 9.2 \times 10^6$

$\therefore\ Q = 1.512 \times 10^6 + 9.2 \times 10^6$

$\therefore\ Q = 1.07 \times 10^7\ J$

$\therefore\ Q = 1.1 \times 10^7\ J$

Question 61

$Q_1 = mc\Delta T$

$= 1 \times 4200 \times 100$

$= 4.2 \times 10^5\ J$

$Q2 = mL$

$= 1 \times 2.3 \times 10^6$

$= 2.3 \times 10^6\ J$

$Q_{TOT} = Q_{1+} Q_2$

$= 0.42 \times 10^6 + 2.3 \times 10^6$

$= 2.72 \times 10^6\ J$

Question 62

$Q = 0.4 \times 3.35 \times 10^5 + 0.4 \times 4200 \times 100$

$+ 0.4 \times 2.3 \times 10^6$

$= 1.222 \times 10^6$

$= 1.2\ MJ$

Question 63

$Q = ML$

$= 5.5 \times 3.35 \times 10^5$

$= 1.8425 \times 10^6\ J$

$= 1.8\ MJ$

Question 64

$Q = ML$

$= 0.35 \times 2.3 \times 10^6$

$= 8.05 \times 10^5\ J$

Question 65

Ice to water requires

$Q = 0.1 \times 3.35 \times 10^5$

$= 3.35 \times 10^4$ J

Steam to water releases

$Q = 0.02 \times 2.3 \times 10^6$

$= 4.6 \times 10^4$ J

Therefore the excess energy is used to heat up the water.

$4.6 \times 10^4 - 3.35 \times 10^4 = 1.25 \times 10^4$

Use $mc\Delta T = 1.25 \times 10^4$

$\therefore\ 0.12 \times 4200 \times \Delta T = 1.25 \times 10^4$

$\therefore\ \Delta T = 24.8$

Hence, final temperature is 25 °C
and it will be a mixture of ice and water.

Question 66

$$Q = \frac{kA\,(T_{body} - T_{external})t}{d}$$

$$= \frac{0.1 \times 0.0001 \times (30 - 0) \times 60}{0.003}$$

$= 6$ J

Question 67

a.

$$Q = \frac{kA\,(T_{body} - T_{external})t}{d}$$

$$= \frac{0.13 \times 150 \times (20 - 12)}{0.04}$$

$= 3900$ J / s

$= 3.9$ kJ / s

b.

$$Q = \frac{kA\,(T_{body} - T_{external})t}{d}$$

$$= \frac{0.04 \times 150 \times (20 - 12)}{0.08}$$

$= 600$ J / s

Question 68

a.

$$Q = \frac{kA\,(T_{body} - T_{external})t}{d}$$

$$= \frac{79 \times 0.1 \times 250}{0.008}$$

$= 246875$ J

$= 250$ kJ (to two s.f.)

b.

$$Q = \frac{kA\,(T_{body} - T_{external})t}{d}$$

$$= \frac{400 \times 0.1 \times 250}{0.008}$$

$= 1250\,000$ J

$= 1.3$ MJ (or 1.3×10^6 J)

Question 69

Because it doesn't expand very much when it changes temperature and so it is less likely to crack or shatter due to changes in temperature

Question 70

Steel, because it expands the least. It expands the same amount as concrete, so it won't crack the concrete when it heats up.

Question 71

Steel expands 1×10^{-5} m per meter per degree

Therefore,

$1 \times 10^{-5} \times 1000 \times 10$

$= 0.1$m

Question 72

Because they will contract when cooled and if they were not slack they would slap as they contracted.

Question 73

So they don't leak or explode when they expand due to heating.

Question 74

i) gas condensing to small amounts of liquid water

ii) solid melting and becoming liquid

iii) evaporation from liquid to gas

Question 75

D) Gases and liquids

Question 76

B) -127 and -33

Question 77

i) darker
ii) matte

Question 78

C) Metal A = aluminium, metal B = brass

Question 79

Conduction

Question 80

Radiation

Question 81

Convection

Question 82

Convection

Question 83

Convection

Question 84

Convection

Question 85

Conduction

Question 86

Conduction

Question 87

Convection

Question 88

Radiation

Question 89

Using Wien's Law

$$\lambda = \frac{2.9 \times 10^{-3}}{T}$$

The higher the temperature the smaller (shorter) the peak wavelength.
Shorter wavelength
$\therefore$ A

Question 90

a.

$$\lambda max = \frac{2.9 \times 10^{-3}}{310}$$

$$= 9.4 \times 10^{-6} \text{ m}$$

b.
Infrared

Question 91

a.

$$T = \frac{2.9 \times 10^{-3}}{\lambda max}$$

$$= \frac{2.9 \times 10^{-3}}{4 \times 10^{-7}}$$

$$= 7.25 \times 10^{3} \text{ K}$$

The sun is 5.8×10^3 K, so this star is 1.45×10^3 K hotter.

b.

$$T = \frac{2.9 \times 10^{-3}}{4 \times 10^{-7}}$$

$$= 4.1 \times 10^{3}$$

$$= 4100 \text{ K}$$

The red star is 1700 K cooler than the sun.

Question 92

a.

$$P = \sigma T^4$$

$$= \frac{5.67 \times 10^{-8} \times 753^4}{5.67 \times 10^{-8} \times 293^4}$$

$$= 44 \text{ times as much energy}$$

b.

$$\frac{P_{hot}}{P_{cold}} = \left(\frac{T_{hot}}{T_{cold}}\right)^4$$

$$10 = \left(\frac{T_{hot}}{293}\right)^4$$

$$\frac{T_{hot}}{293} = \sqrt[4]{10}$$

$$T_{hot} = 293 \times \sqrt[4]{10}$$

$$= 521 K$$

$$= 248\ °C$$

Therefore it is 248 – 20 = 228 °C hotter.

Question 93

a.

$$T = \frac{2.9 \times 10^{-3}}{650 \times 10^{-9}}$$

$$= 4.5 \times 10^3 K$$

b.

$$A = 4\pi r^2$$

$$= 4\pi \times (700\,000)^2$$

$$= 6.2 \times 10^{12}\ m^2$$

c.

$$P = \sigma T^4$$

$$= 5.67 \times 10^{-8} \times (2.9 \times 10^3 / 650 \times 10^{-9})^4$$

$$= 2.2 \times 10^7\ W\ m^{-2}$$

Question 94

a.

Red

b.

Violet

Question 95

Breaks up into ROYGBIV

Question 96

a.

T = 0.005s

b.

$$f = \frac{1}{0.005}$$

$$= 200\ Hz$$

Question 97

$$c = f\,\lambda$$

$$\lambda = \frac{c}{f}$$

$$= \frac{3 \times 10^8}{105.1 \times 10^6}$$

$$= 2.9\ m$$

Question 98

D) The transfer of energy
