Unit 9 · Heat and Temperature

HARDER PRACTICE QUESTIONS · ANSWER KEY

Full marks 25

Give the marks for the points in the marking scheme; an answer in other words that says the same is right.

1 Spot the error

ANSWER U · 3

He has converted a **change** as if it were a reading. The +32 shifts the zero of the scale; it cancels in a difference. For a change, $\Delta F = (9/5)\Delta C = 9 \times 20 \div 5 =$ **36 °F**. (68 °F is the reading at which water at 20 °C stands, not a rise.)

MARKING SCHEME

- ✓ The mistake: a change of temperature converted with the +32.
- ✓ For a change, $\Delta F = (9/5)\Delta C$.
- ✓ A rise of 36 °F.

2 Predict, then explain

ANSWER A · 4

i. **Yes**: their degrees are different sizes, so the readings must cross somewhere.

ii. $F = (9/5)(K - 273.15) + 32$. Setting F = K: $K = 1.8K - 491.67 + 32$, so $0.8K = 459.67$ and **K = F = 574.6** (about 301 °C).

iii. **No.** Their degrees are the same size, so K is always 273.15 more than C: the readings never meet.

MARKING SCHEME

- ✓ Yes, because the degrees differ in size.
- ✓ F = K solved.
- ✓ 574.6.
- ✓ Kelvin and Celsius never agree: same degree, always 273.15 apart.

3 Read the data

ANSWER HA · 4

i. $\theta = (120.0 - 100.0) \div (136.6 - 100.0) \times 100 = 20 \div 36.6 \times 100 =$ **54.6 °C**.

ii. The pressure falls by 36.6 kPa for 100 degrees, 0.366 kPa per degree. From 100.0 kPa to zero takes $100.0 \div 0.366 = 273.2$ degrees, so $\theta =$ **−273.2 °C**.

iii. **Absolute zero**, 0 K (−273.15 °C). A pressure can't be less than zero, and at absolute zero the molecules have the least possible energy, so there is nothing more to take away (a real gas turns liquid before getting there).

MARKING SCHEME

- ✓ $\theta = (P - P_0)/(P_{100} - P_0) \times 100 = 54.6$ °C.
- ✓ Zero pressure at about −273 °C.
- ✓ Absolute zero.
- ✓ No lower temperature: the pressure (and the molecules' energy) can't fall below zero.

4 Calibrated in Bhaktapur

ANSWER A · 3

i. His 100 divisions cover 95 real degrees, so each division is 0.95 °C. At 50 °C it reads $50 \div 0.95 =$ **52.6**.

ii. **No.** The error is zero at 0, 2.6 at 50 °C and 5 at 95 °C: it grows in proportion to the temperature.

MARKING SCHEME

- ✓ Each division is 0.95 °C.
- ✓ It reads 52.6.
- ✓ The error grows along the scale (0 at the ice point, 5 at the top).

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5 Two thermometers that disagree

ANSWER U · 3

Not necessarily. Each scale assumes its thermometric property changes uniformly between the fixed points. They agree exactly at 0 and 100, but mercury's volume and platinum's resistance don't change in exactly the same way with temperature, so in between they can differ by a few tenths of a degree. Accurate work uses one agreed standard, the gas thermometer (and the kelvin as defined).

MARKING SCHEME

- ✓ Not faulty: both agree at the fixed points by construction.
- ✓ Different properties don't change in exactly the same way between them.
- ✓ A standard thermometer (the gas thermometer) settles which is right.

6 Correct the misconceptions

ANSWER U · 3

1. There is no flow of "cold": heat flows from the hand (hotter) into the ice.
2. A body doesn't "have" heat: heat is energy in transfer. The iceberg has more thermal energy, but the tea is hotter.
3. Temperature measures the **average** kinetic energy of the molecules, not the total thermal energy; a large body at a low temperature can hold more thermal energy than a small hot one.

MARKING SCHEME

- ✓ Heat flows from the hand to the ice; there is no flow of cold.
- ✓ Heat is energy in transfer, not something a body holds.
- ✓ Temperature measures the average, not the total, kinetic energy of the molecules.

7 Think

ANSWER HA · 3

No. A thermometer (C) is placed in contact with body A until it is in equilibrium, and reads a number; then with B. If they read the same, we conclude that A and B would be in equilibrium with each other, with no heat flowing if they touched. That step is exactly the zeroth law. Without it, two bodies giving the same reading might still exchange heat, and the reading would not tell us anything about the bodies themselves.

MARKING SCHEME

- ✓ The thermometer is C, put in equilibrium with A and then with B.
- ✓ Equal readings let us conclude A and B are in equilibrium: that is the zeroth law.
- ✓ Without it, equal readings would not mean equal temperatures.

8 Make your own

ANSWER HA · 2

Each degree of the new scale is $37/100 = 0.37\ ^\circ\text{C}$, so the reading is $X = C \div 0.37 = 100C/37$. Boiling water: $100 \times 100 \div 37 \approx$ **270**. Check: body temperature $100 \times 37 \div 37 = 100$.

MARKING SCHEME

- ✓ $X = 100C/37$ (or the same fraction from the two fixed points).
- ✓ Boiling water about 270, checked.

See it at Science Playground

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- **Which Feels Cooler?** (exhibit): The wood and the metal have long been in thermal equilibrium with the room, at one temperature, yet the metal feels colder to your hand.
- **Galileo Thermometer** (exhibit): A thermometer needs a property that changes steadily with temperature; this one uses the liquid's density: read the tag on the lowest bulb still floating.

Marks by level	Knowledge	Understanding	Application	Higher ability	Total
Marks	0	9	7	9	**25**

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