1. Internal energy is the sum of which energies?

   ☐ the bulk kinetic energy of the whole object

   ☐ the random kinetic energy of the molecules

   ☐ the potential energy between the molecules

   ☐ the weight of the object

   Tick every correct option.

2. The work done by a gas expanding at constant pressure is:

   ☐ $\dfrac{\Delta V}{p}$

   ☐ $\dfrac{p}{\Delta V}$

   ☐ $p\,\Delta V$

   ☐ pV^2

3. Which is the full two-mark definition of internal energy?

   ☐ the kinetic energy of the object as a whole as it moves

   ☐ the heat supplied to the object since it was made

   ☐ the sum of the random distribution of the kinetic and potential energies of the molecules

   ☐ the total kinetic energy of all the molecules in the object

4. When a gas expands, it does work on its surroundings.

   ☐ True ☐ False

5. A moving train's bulk kinetic energy counts as part of its internal energy.

   ☐ True ☐ False

6. A gas expands. In this syllabus's convention, what is the sign of W, the work done ON the gas?

   ☐ it depends on the temperature

   ☐ zero

   ☐ positive, because work is being done

   ☐ negative, because the gas loses energy to its surroundings

7. A tanker of gas driving along a motorway has more internal energy than the same tanker parked, at the same temperature.

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8. The first law of thermodynamics: $\Delta U = q +$ _____.

   _____

9. Internal energy depends only on the state of the system, not on the path taken to reach it.

   ☐ True ☐ False

10. A two-mark statement of the first law must define its symbols with direction. Which are correct? Select **all** that apply.

    ☐ ΔU is the increase in internal energy of the system

    ☐ q is the thermal energy transferred TO the system by heating

    ☐ W is the work done ON the system

    ☐ W is the work done BY the system

    Tick every correct option.

1. **the random kinetic energy of the molecules; the potential energy between the molecules**

   Internal energy = random molecular KE + intermolecular PE. The object's overall motion (bulk KE) is separate.

2. $p\,\Delta V$

   Force = pA, distance = Δx, so work = $pA\Delta x = p\,\Delta V$.

3. **the sum of the random distribution of the kinetic and potential energies of the molecules**

   Both marks need "kinetic and potential" and the word "random". Without "random" the phrase describes a moving object's energy instead.

4. **True**

   Yes – it pushes the piston/atmosphere outward. So the work done *on* the gas is negative.

5. **False**

   No – internal energy is the energy of the *random* molecular motion, not the whole object moving along.

6. **negative, because the gas loses energy to its surroundings**

   Work done BY the gas and work done ON it are equal in size and opposite in sign. Confusing the two is the commonest error in this topic.

7. **False**

   Bulk motion is not internal energy. The random molecular motion is unchanged, so U is the same; the lorry simply also has kinetic energy.

8. **W**

   $\Delta U = q + W$, where W is the work done **on** the gas and q is the heat added.

9. **True**

   Yes – U is a function of state (T, p, V, amount); two routes to the same state give the same U.

10. **ΔU is the increase in internal energy of the system; q is the thermal energy transferred TO the system by heating; W is the work done ON the system**

    "To the system" and "on the system" are where the marks are. Defining W as the work done by the system flips the sign of the whole equation.

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