16. Thermodynamics

16.1 Internal energy

Paper 4

Marking Scheme

Q1.

(b)(iii)	internal energy = total KE + PE of molecules **or** PE = 0 so internal energy = total KE of molecules	**B1**
	internal energy = $1.3 \times 10^{25} \times 6.0 \times 10^{-21}$ $= 7.8 \times 10^{4}$ J	**A1**
(c)	straight line with positive gradient	**B1**
	line passing through the origin	**B1**

Q2.

(a)	sum of potential energy and kinetic energy	**B1**
	(total) energy of random motion of particles	**B1**
(b)(i)	no change in separation so no change in (molecular) potential energy	**B1**
	temperature increases so kinetic energy (of molecules) increases	**B1**
	kinetic energy increases and potential energy unchanged, so internal energy increases	**B1**
(b)(ii)	temperature constant so no change in (molecular) kinetic energy	**B1**
	separation increases so potential energy (of molecules) increases	**B1**
	potential energy increases and kinetic energy unchanged, so internal energy increases	**B1**

Q3.

(a)	sum of potential energy and kinetic energy (of particles)	**B1**
	(total) energy of random motion of particles	**B1**

Q4.

(c)(i)	$\Delta U = 3/2 \times k \times \Delta T \times N$	**C1**
	$= 3/2 \times 1.38 \times 10^{-23} \times (288 - 310) \times 1.4 \times 10^{23}$	**C1**
	$= -64$ J	**A1**

Q5.

(b)(ii)	$\Delta U = 3/2 \times k \times \Delta T \times N$	**C1**
	$= 3/2 \times 1.38 \times 10^{-23} \times (190 - 290) \times 6.6 \times 10^{23}$	**C1**
	$= -1400$ J	**A1**

Q6.

(b)(iii)	internal energy = ΣE_K (of molecules) + ΣE_P (of molecules) **or** no forces between molecules	**B1**
	potential energy of molecules is zero	**B1**

Q7.

(a)	total potential energy and kinetic energy (of molecules/atoms)	**M1**
	reference to random motion of molecules/atoms	**A1**
(b)	(in ideal gas,) no intermolecular forces	**B1**
	no potential energy (so change in kinetic energy is change in internal energy)	**B1**
(c)	(random) potential energy of molecules does not change	**M1**
	(random) kinetic energy of molecules does not change	**M1**
	so internal energy does not change	**A1**
	or	
	decrease in total potential energy = gain in total kinetic energy	**(M1)**
	no external energy supplied	**(M1)**
	so internal energy does not change	**(A1)**
	or	
	no compression (of ball) so no work done on the ball	**(M1)**
	no resistive forces so no heating of the ball	**(M1)**
	so internal energy does not change	**(A1)**
(c)	**or**	
	no change of state so potential energy (of molecules) unchanged	**(M1)**
	no temperature rise so kinetic energy (of molecules) unchanged	**(M1)**
	so internal energy does not change	**(A1)**

Q8.

(b)(ii)	no (total) change (in internal energy)	**B1**
	gas returns to its original temperature	**B1**

Q9.

(b)(i)	no change (in internal energy)	**B1**
	(because) no change in temperature	**B1**

Q10.

(b)(ii)	energy transfer = (0.349 **or** 0.35) × 12.5 × (310 – 290)	**C1**
	= 87.3 J **or** 87.5 J	**A1**

Q11.

(a)(i)	sum of potential and kinetic energies (of molecules/atoms/particles)	**B1**
	(energy of) molecules/atoms/particles in random motion	**B1**
(a)(ii)	(in ideal gas) no intermolecular forces so no potential energy	**B1**
	internal energy is (solely) kinetic energy (of particles)	**B1**
	(mean) kinetic energy (of particles) proportional to (thermodynamic) temperature of gas	**B1**

Q12.

(a)	sum of potential and kinetic energies (of molecules/atoms/particles)	**B1**
	(energy of) molecules/atoms/particles in random motion	**B1**
(b)(i)	final temperature = initial temperature	**B1**
	no change in internal energy	**B1**