

- 1 (a)(i) 49 minutes (allow 48 minutes 58 or 59 seconds) 1
 47 minutes (allow 47 minutes 1 or 2 seconds) 1
 (ii) minimum 98 km h⁻¹ 1
 maximum 102 km h⁻¹ 1
 (iii) 100 ± 2 km h⁻¹ 1
 (iv) 2% 1 6
 (b) e.g. use a different clock 1
 which will measure time to the nearest second 1
 e.g. use the car odometer 1
 which will be more accurate than a distance from a map 1 4
 OR e.g. use the marker posts on the motorway (1)
 Which will enable an accurate distance to be found (1)
 For each improvement allow one mark for a bald statement and the second
 Mark for sensible elaboration.
- 2 (a) The sum of the kinetic (and potential) energies of all the atoms (in the gas) 1
 inclusion of the word 'random' when applied to kinetic energies 1 2
 (b) (i) total mass / mass of one atom 1
 = 0.020 (kg) / 6.6 × 10⁻²⁶ (kg) 1
 = 3.03 × 10²³ atoms 0 2
 (ii) kinetic energy = $\frac{1}{2} \times 6.6 \times 10^{-26} \times (440)^2$ 1
 = 6.39 × 10⁻²¹ J 1 2
 (iii) 1 eV = 1.6 × 10⁻¹⁹ J 1
 4.3 MeV = 6.88 × 10⁻¹³ J 1
 ratio required = $6.88 \times 10^{-13} / 6.39 \times 10^{-21} = 1.08 \times 10^8$ 1 3
 (c) (i) 19.5 % of 3.0 × 10²³ (= 5.85 × 10²²) 1 1
 (ii) 1% + 2½ % = 3½ %, 3½ % of 3.0 × 10²³ (= 1.05 × 10²²) 1 1
 (iii) total is 98.5 % 1
 1.5 % of 3.0 × 10²³ = 4.5 × 10²¹ 1 2
 (iv) twice average speed = 880 m s⁻¹ 1
 percentage less than 900 m s⁻¹ = 97 % 1
 percentage between 880 m s⁻¹ and 900 m s⁻¹ about 0.8 %
 giving 3.8 % = approx. 4 % 1 3
 (d) sketch shows more atoms at higher speed 1
 and fewer atoms at lower speed 1 2
 (e) 1 for fact 1 for brief explanation (Allow 1 for just 'change of state') 2 2
 e.g. a liquid cools when it evaporates because 1
 faster atoms escape more readily (than slow ones) 1
 OR e.g. a liquid evaporates more quickly at high temperature because
 more rapid evaporation from the surface of a liquid
 OR e.g. fast atoms in upper atmosphere may reach escape velocity

- 3 (a) velocity (allow speed) 1 1
 (b) (i) 3.4 (± 0.2) s 1 1
 (ii) e.g. gradient = $(114 - 8)/(5 - 2) =$ 1
 $= 35 (\pm 4) \text{ m s}^{-1}$ 1 2
 (c) (i) Straight line through origin 1
 additional detail given e.g. one of gradient approx 10, slight curve at end, 1 2
 (ii) upward curve to zero at 4.9 (± 0.2) s 1
 positive half loop to zero at 7.9 (± 0.2) s 1 2

(d)

distance of fall/ m	gravitational p.e. /J	elastic p.e. /J	kinetic energy /J
0	54 000	0	0
20	42 000	0	12 000
40	30 000	0	24 000
50 (unstretched length)	24 000	0	30 000
59 (equilibrium position)	18 600	2700	32700
90 (bottom)	0	54 000	0

[1] mark for each entry

PLUS an extra mark correct method for 2700 J = $\frac{1}{2} \times 67.5 \times 9^2$

9 9

- (e) resultant force equal to zero 1
 OR upward force (due to rope) = downward force (weight)
 TWO further ideas required
 e.g. increase air resistance 1
 by spread-eagle position, or by wearing clothes with more drag 1
 e.g. using different elastic in the rope 1
 with greater hysteresis 1 5 22
 e.g. less mass
 difficult for a particular person
 e.g. increase the damping (allow one mark only unless a reason is given)

- 4 (a) As a region in which a (remote) force acts on something 1
 e.g. on a mass or a charge or a current in a wire (two only required) 1 2
 (b) Example given 1
 diagram appropriate 1
 explanation of use 1
x 2 for second example 3 6 8
 e.g. gravitational field. If this is measured (accurately) over a region, a reduced value of g can indicate a low density region –perhaps where oil exists
 e.g. electrical field. If this is found experimentally near an irregularly shaped object the field is strong near points, (lightning conductor) Made use of in field ion microscope to ‘see’ atoms – as frequently illustrated in false colour