IB Physics SL: Newton- Kinematics Markscheme

1. (a) *[1] for each appropriate and valid point e.g.*
thermal energy is the K.E. of the component particles of an object;
thus measured in joules;
the temperature of an object is a measure how hot something is (it can be used to work out the direction of the natural flow of thermal energy between two objects in thermal contact) / measure of the average K.E. of molecules;
it is measured on a defined scale (Celsius, Kelvin *etc*.); 4 max

(b) (i) correct substitution: energy = power × time;
= 1200 W × (30 × 60) s;
= 2.2 × 10 J 2 max

(ii) use of $E = m\,c\,\Delta\theta$;
to get $\Delta\theta = 2.2 \times 10^6 / (4200 \times 70)$ K;
= 7.5 K; 3 max

(c) *[1] naming each process up to **[3 max]**.*
convection;
conduction;
radiation;

*[1] for an appropriate (matching) piece of information / outline for each process up to **[3 max]**.*

e.g. convection is the transfer of thermal energy via bulk movement of a gas due to a change of density;
conduction is transfer of thermal energy via intermolecular collisions;
radiation is the transfer of thermal energy via electromagnetic waves (IR part of the electromagnetic spectrum in this situation) / *OWTTE*; 6 max

(d) (i) *[1] for each valid and relevant point e.g.*
in evaporation the faster moving molecules escape;
this means the average K.E. of the sample left has fallen;
a fall in average K.E. is the same as a fall in temperature; 3 max

(ii) energy lost by evaporation = 50 % × 2.2×10^6 J;
= 1.1×10^6 J;
correct substitution into $E = m\,l$
to give mass lost = 1.1×10^6 J / 2.26×10^6 J kg^{-1}
= 0.487 kg
= 487 g; 3 max

(iii) *[1] for any valid and relevant factors **[2 max]** e.g.*
area of skin exposed;
presence or absence of wind;
temperature of air;
humidity of air *etc*.;

*[1] for appropriate and matching explanations **[2 max]** e.g.*
increased area means greater total evaporation rate;
presence of wind means greater total evaporation rate;
evaporation rate depends on temperature difference;
increased humidity decreases total evaporation rate *etc*.; 4 max

[25]

2. B

[1]

3. B

[1]

4. B

[1]

5. A

[1]

6. (a)

	(i)	acceleration;	1 max
	(ii)	velocity;	1 max
(b)	(i)	$KE = \frac{1}{2}mv^2 = 0.08 \times 225 = 18$ J;	1 max
	(ii)	18 J;	1 max
	(iii)	loss in $PE = mgh = 40$ J;	1 max
	(iv)	total $KE = 58$ J;	
		$v = \sqrt{\frac{116}{0.16}} = 27 \text{ m s}^{-1}$;	2 max

[7]

7. C

[1]

8. B

[1]

9. A

[1]

10. C

[1]

11. D

[1]

12. A

[1]

13. A

[1]

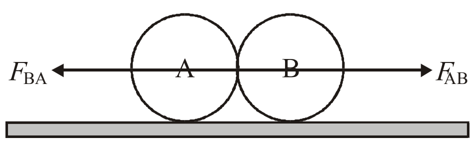
14. (a) when two bodies A and B interact, the force that A exerts on B is equal and opposite to the force that B exerts on A;
or
when a force acts on a body an equal and opposite force acts on another body somewhere in the universe; 1 max

Award ***[0]*** *for "action and reaction are equal and opposite" unless they explain what is meant by the terms.*

(b) if the net external force acting on a system is zero;
then the total momentum of the system is constant (or in any one direction, is constant); 2

To achieve ***[2]*** *answers should mention forces and should show what is meant by conserved. Award* ***[1 max]*** *for a definition such as "for a system of colliding bodies, the momentum is constant" and* ***[0]*** *for "a system of colliding bodies, momentum is conserved".*

(c)



arrows of equal length;
acting through centre of spheres;
correct labelling consistent with correct direction; 3

(d) (i) *Ball B:*
change in momentum = Mv_B;
hence $F_{AB}\Delta t = Mv_B$; 2

(ii) *Ball A:*
change in momentum = $M(v_A - V)$;
hence from Newton 2, $F_{BA}\Delta t = M(v_A - V)$; 2

(e) from Newton 3, $F_{AB} + F_{BA} = 0$, ***or*** $F_{AB} = -F_{BA}$;
therefore $-M(v_A - V) = Mv$;
therefore $MV = Mv_B + Mv_A$;
that is, momentum before equals momentum after collision such that the net change in momentum is zero (unchanged) / *OWTTE*; 4

Some statement is required to get the fourth mark i.e. an interpretation of the maths result.

(f) from conservation of momentum $V = v_B + v_A$;
from conservation of energy $V^2 = v_B^2 + v_A^2$;
if $v_A = 0$, then both these show that $v_B = V$;
or
from conservation of momentum $V = v_B + v_A$;
from conservation of energy $V^2 = v_B^2 + v_A^2$;
so, $V^2 = (v_B + v_A) = v_B^2 + v_A^2 + 2v_Av_B$ therefore v_A has to be zero; 3 max

Answers must show that effectively, the only way that both momentum and energy conservation can be satisfied is that ball A comes to rest and ball B moves off with speed V.

[17]