The following list of formulae may be found useful :

Energy transfer during heating or cooling $E = mc\Delta T$

Part A : HKCE examination questions

1. **< HKCE 1980 Paper II - 15 >**

When a mercury thermometer is immersed in melting ice and then in steam, the lengths of the mercury thread in the stem are respectively 2 cm and 22 cm. When the thermometer is put in a water bath, the length of the thread is 11 cm. What is the temperature of the water bath ?

A. 40°C
B. 45°C
C. 50°C
D. 55°C

2. **< HKCE 1984 Paper II - 13 >**

An equal quantity of heat is supplied to each of the following substances and the corresponding rises in temperature are recorded. Which of the following substances has the smallest specific heat capacity ?

	Substance	Mass (kg)	Rise in temperature (°C)
A.	*P*	2.5	5
B.	*Q*	3.0	4
C.	*R*	4.5	3
D.	*S*	5.0	3

3. **< HKCE 1986 Paper II - 16 >**

The heat capacity of an object depends on its
(1) material
(2) mass
(3) shape

A. (1) only
B. (3) only
C. (1) & (2) only
D. (2) & (3) only

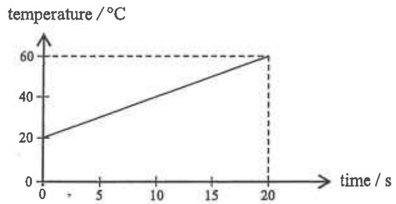
4. **< HKCE 1987 Paper II - 25 >**

Which of the following pairs of objects have different specific heat capacities ?

A. 1 kg of water and 2 kg of water
B. 1 kg of liquid naphthalene and 1 kg of solid naphthalene
C. 1 kg of oil in a glass container and 1 kg of oil in a metal container
D. 1 kg of water at 15°C and 1 kg of water at 30°C

5. **< HKCE 1988 Paper II - 12 >**

The graph shows the relationship between temperature and time when 1 kg of a liquid is heated by a 500 W immersion heater. Assuming no loss of heat, what is the specific heat capacity of the liquid ?



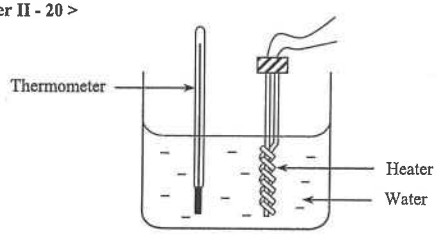
A. 0.01 J kg^{-1} °C^{-1}
B. 250 J kg^{-1} °C^{-1}
C. 420 J kg^{-1} °C^{-1}
D. 2500 J kg^{-1} °C^{-1}

6. **< HKCE 1989 Paper II - 20 >**

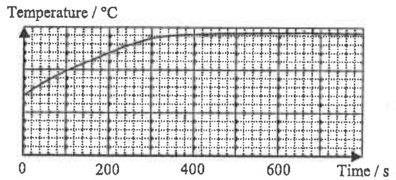
A heater supplies energy to a liquid of mass 0.5 kg and specific heat capacity 4000 J kg^{-1} °C^{-1} contained in a vessel of negligible heat capacity. Assume that the heat exchange with the surroundings can be neglected. If the temperature of the liquid rises from 10°C to 70°C in 100 s, the power of the heater is

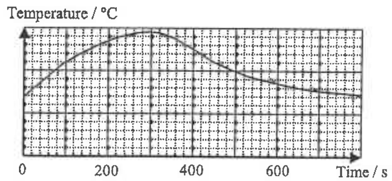
A. 200 W
B. 1200 W
C. 1400 W
D. 12000 W

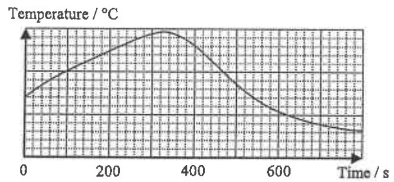
7. **< HKCE 1992 Paper II - 20 >**

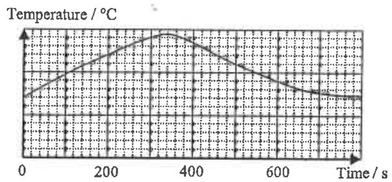


In the diagram shown, the water is initially at room temperature. The electric heater is switched on for 300 s and then switched off. Which of the following graphs correctly describes the variation of the reading of the thermometer ?

A.


B.


C.


D.


8. **< HKCE 1993 Paper II - 18 >**

An energy of 16500 J is supplied to a metal block of mass 0.5 kg and its rise in temperature is 64°C. The specific heat capacity of the metal is

A. $\dfrac{16500 \times 0.5}{64 + 273}$ J kg^{-1} °C^{-1}

B. $\dfrac{16500 \times 64}{0.5}$ J kg^{-1} °C^{-1}

C. $\dfrac{16500}{64 \times 0.5}$ J kg^{-1} °C^{-1}

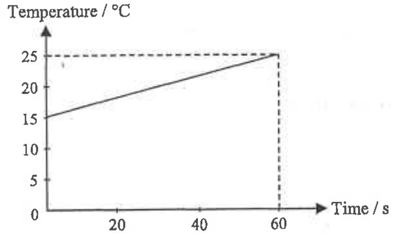
D. $\dfrac{16500}{(64 + 273) \times 0.5}$ J kg^{-1} °C^{-1}

9. **< HKCE 1993 Paper II - 16 >**

Water is used as a coolant in motor car engines because

A. water has a low specific heat capacity.
B. water has a high specific heat capacity.
C. water has a low specific latent heat of vaporization.
D. water has a high specific latent heat of vaporization.

15. **< HKCE 1998 Paper II - 21 >**



The graph shows the variation of the temperature of liquid with time when the liquid is heated by a 400 W heater. The mass of the liquid is 2 kg. Find the specific heat capacity of the liquid. Assume all the energy given out by the heater is absorbed by the liquid.

A. 83 J kg^{-1} °C^{-1}
B. 480 J kg^{-1} °C^{-1}
C. 1200 J kg^{-1} °C^{-1}
D. 2400 J kg^{-1} °C^{-1}

16. **< HKCE 1998 Paper II - 19 >**

Which of the following statements about internal energy, heat and temperature is/are true ?

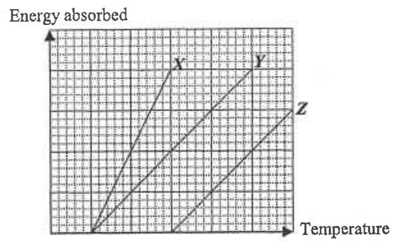
(1) The internal energy of a body is a measure of the total kinetic energy and potential energy of the molecules in the body.

(2) Two bodies of the same temperature always have the same amount of internal energy.

(3) Heat is a measure of the energy transferred from one body to another as a result of temperature difference between the two bodies.

A. (1) only
B. (2) only
C. (1) & (3) only
D. (2) & (3) only

17. **< HKCE 1999 Paper II - 16 >**



Equal masses of liquids *X*, *Y* and *Z* are separately heated. The graph shows the variation of the energies absorbed by the liquids with their temperatures. Let c_X, c_Y and c_Z be the specific heat capacities of *X*, *Y* and *Z* respectively. Which of the following relations is correct ?

A. $c_X = c_Y > c_Z$
B. $c_X = c_Y < c_Z$
C. $c_X < c_Y = c_Z$
D. $c_X > c_Y = c_Z$

10. **< HKCE 1994 Paper II - 16 >**

An equal amount of energy is supplied to each of the following substance. Which one of them has the smallest rise in temperature ?

	Substance	Mass / kg	Specific heat capacity / J kg^{-1} °C^{-1}
A.	*P*	1	4200
B.	*Q*	2	2300
C.	*R*	3	2200
D.	*S*	4	900

11. **< HKCE 1995 Paper II - 18 >**

Which of the following statements about heat is/are true ?

(1) Heat is used to describe the total energy stored in a body.
(2) Heat is used to describe the energy transferred from one body to another as a result of a temperature difference between them.
(3) A body's internal energy is increased when it is heated.

A. (1) only
B. (2) only
C. (1) & (3) only
D. (2) & (3) only

12. **< HKCE 1996 Paper II - 18 >**

Which of the following phenomena concerning water can be explained by its high specific heat capacity ?

(1) Water is used as a coolant in car engines.
(2) Inland areas generally have hotter summers and colder winters than coastal areas of similar latitude and altitude.
(3) The body temperature of human beings changes slowly even when the surrounding temperature changes sharply.

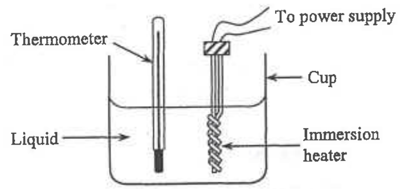
A. (2) only
B. (1) & (2) only
C. (1) & (3) only
D. (1), (2) & (3)

13. **< HKCE 1997 Paper II - 19 >**

The apparatus is used to find the specific heat capacity of a liquid. Which of the following can improve the accuracy of the experiment ?

(1) Take the final temperature of the liquid immediately after switching off the power supply.
(2) Cover the cup with a lid.
(3) Stir the liquid throughout the experiment.

A. (1) only
B. (1) & (2) only
C. (2) & (3) only
D. (1), (2) & (3)



14. **< HKCE 1997 Paper II - 20 >**

An heater with a power of 100 W is used to heat 0.3 kg of a liquid which has a specific heat capacity of 2000 J kg^{-1} °C^{-1}. If the initial temperature of the liquid is 23°C, find its temperature after 2 minutes. Assume all the energy given out by the heater is absorbed by the liquid.

A. $(\frac{100 \times 120}{0.3 \times 2000} + 23)$ °C

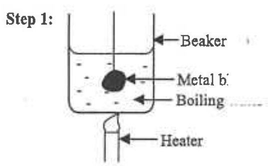
B. $(\frac{0.3 \times 2000 \times 23 \times 2}{100})$ °C

C. $(\frac{100 \times 120 \times 0.3}{2000} + 23)$ °C

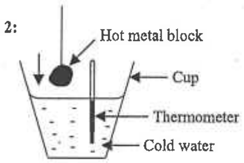
D. $(\frac{0.3 \times 2000}{100 \times 120} + 23)$ °C

Questions 21 and 22 : The specific heat capacity of a metal is measured using the following method :

Step 1:



Step 2:



A metal block is first immersed in boiling water for some time. The block is then transferred to a cup of cold water. After a while, the temperature of the water is measured.

21. **< HKCE 2002 Paper II - 20 >**

The result of the experiment is as follows :

Mass of metal block = 0.8 kg

Mass of water in the cup = 0.3 kg

Initial temperature of water in the cup = 23°C

Final temperature of water in the cup = 38°C

Find the specific heat capacity of the metal (in J kg^{-1} °C^{-1}).

(Given : Specific heat capacity of water = 4200 J kg^{-1} °C^{-1}.)

A. 236
B. 381
C. 622
D. 953

22. **< HKCE 2002 Paper II - 21 >**

The result obtained in the last question is found to be higher than the true value of the specific heat capacity of the metal. Which of the following is a probable reason ?

A. Some hot water is still adhered to the metal block when the block is transferred to the cold water.
B. Some energy is lost to the surroundings when the metal block is transferred to the cold water.
C. Some energy is absorbed by the cup.
D. The temperature of the metal block is still higher than 38°C when the final temperature of the water in the cup is measured.

23. **< HKCE 2003 Paper II - 19 >**

If there is no heat flow between two bodes when they are in contact, then the two bodies must have the same

A. temperature.
B. internal energy.
C. specific heat capacity.
D. specific latent heat of vaporization.

24. **< HKCE 2003 Paper II - 22 >**

A student uses an electric kettle to heat 0.5 kg of water at 20°C. The water boils in 4 minutes. Estimate the output power of the kettle. The specific heat capacity of water is 4200 J kg^{-1} °C^{-1}.

A. 175 W
B. 700 W
C. 875 W
D. 1400 W

18. **< HKCE 2000 Paper II - 22 >**

An object P has a higher temperature than another object Q. Which of the following statements is/are correct ?

(1) The internal energy of P must be higher than that of Q.
(2) The specific heat capacity of P must be higher than that of Q.
(3) There will be a heat flow from P to Q when they are in contact.

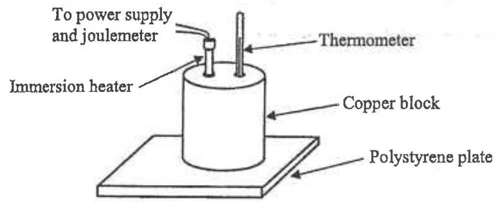
A. (3) only
B. (1) & (2) only
C. (2) & (3) only
D. (1), (2) & (3)

19. **< HKCE 2000 Paper II - 20 >**

Equal amount of four different liquids are separately heated at the same rate. The initial temperatures of the liquids are all 20°C. The boiling points and specific heat capacities of the liquids are shown below. Which one of the following liquids will boil first ?

	Liquid	Boiling point / °C	Specific heat capacity / J kg^{-1} °C^{-1}
A.	P	50	1000
B.	Q	60	530
C.	R	80	850
D.	S	360	140

20. **< HKCE 2001 Paper II - 17 >**



The apparatus shown is used to measure the specific heat capacity of a cylindrical copper block. The result of the experiment is as follows :

Mass of copper block = m kg

Initial temperature = 21°C

Final temperature = 47°C

Initial joulemeter reading = R_1 J

Final joulemeter reading = R_2 J

Which of the following expressions gives the specific heat capacity of copper in J kg^{-1} °C^{-1} ?

A. $\dfrac{m(R_2 - R_1)}{26}$

B. $\dfrac{R_1 - R_2}{26m}$

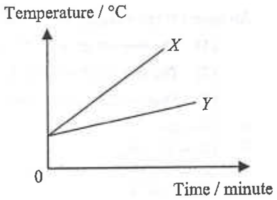
C. $\dfrac{R_2 - R_1}{26m}$

D. $\dfrac{m(R_1 - R_2)}{26}$

30. < HKCE 2010 Paper II - 33 >

The figure shows the temperature-time graph of two objects X and Y when they are heated at the same power. Which of the following deductions are correct ?

(1) The heat capacity of X is smaller.
(2) If X and Y are made of the same material, the mass of X is smaller.
(3) The specific heat capacity of X is smaller.



A. (1) & (2) only
B. (1) & (3) only
C. (2) & (3) only
D. (1), (2) & (3)

31. < HKCE 2011 Paper II - 8 >

Two liquids X and Y are heated by two different heaters. The energy supplied, the mass of the liquid and the temperature rises are recorded as follows.

	Liquid X	**Liquid Y**
Energy supplied / J	24000	18000
Mass / kg	0.3	0.2
Temperature rise / °C	20	25

Which of the following statements are correct ?

(1) The heat capacity of X is larger than that of Y.
(2) The specific heat capacity of X is larger than that of Y.
(3) The heat capacity of X determined remains the same if the experiment is repeated by doubling the mass of X.

A. (1) & (2) only
B. (1) & (3) only
C. (2) & (3) only
D. (1), (2) & (3)

Part B : Supplemental exercise

32. What is the advantages of using mercury in a liquid-in-glass thermometer ?

(1) It expands evenly with rise in temperature.
(2) It is liquid over a convenient range.
(3) It is transparent.

A. (1) & (2) only
B. (1) & (3) only
C. (2) & (3) only
D. (1), (2) & (3)

33. Which of the following can increase the heat capacity of a cup of water ?

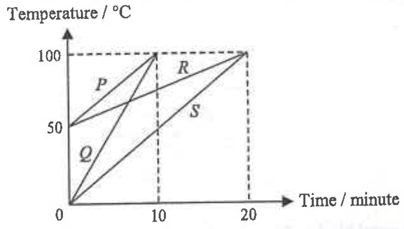
(1) Increase the mass of the water
(2) Increase the temperature of the water
(3) Change the water to another cup

A. (1) only
B. (3) only
C. (1) & (2) only
D. (2) & (3) only

25. < HKCE 2007 Paper II - 10 >

Four liquids P, Q, R and S with the same mass are heated at the same rate. The graph below shows the variation of their temperatures with time.

Which liquid has the highest specific heat capacity ?



A. P
B. Q
C. R
D. S

26. < HKCE 2008 Paper II - 35 >

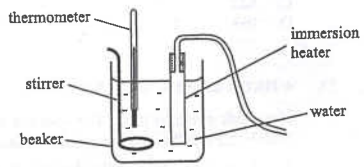
What physical properties does the temperature of an object represent ?

(1) A measure of the degree of hotness of the object.
(2) A measure of the internal energy of the object.
(3) A measure of the average kinetic energy of the molecules of the object.

A. (1) & (2) only
B. (1) & (3) only
C. (2) & (3) only
D. (1), (2) & (3)

27. < HKCE 2008 Paper II - 10 >

A 100 W immersion heater is used to heat 0.5 kg of water, which is being stirred by a stirrer. After 3 minutes, the water temperature increases from 25°C to 30°C. What is the estimated energy loss in this period ? Given : specific heat capacity of water = 4200 J kg^{-1} °C^{-1}



A. 7500 J
B. 10500 J
C. 18000 J
D. 28500 J

28. < HKCE 2009 Paper II - 9 >

Which of the following descriptions about internal energy are correct ?

(1) Different masses of water at the same temperature have the same amount of internal energy.
(2) A copper block has greater internal energy when it is hot than when it is cold.
(3) Water at 0°C has greater internal energy than a block of ice of the same mass at 0°C.

A. (1) & (2) only
B. (1) & (3) only
C. (2) & (3) only
D. (1), (2) & (3)

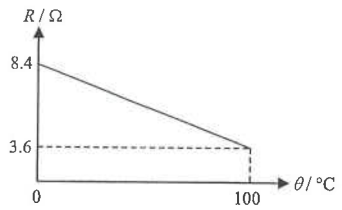
29. < HKCE 2009 Paper II - 33 >

A bottle of 0.5 kg water and a bottle of 0.75 kg water have been stored in a refrigerator for a few days. Which of the following statements are correct ?

(1) The temperatures of the two bottles of water are equal.
(2) The average kinetic energy of the water molecules in the two bottles is equal.
(3) The total potential energy of the water molecules in the two bottles is equal.

A. (1) & (2) only
B. (1) & (3) only
C. (2) & (3) only
D. (1), (2) & (3)

41.



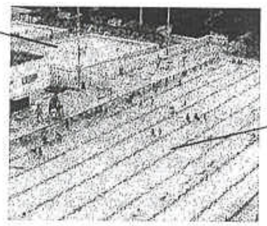
The variation of electrical resistance can be used to determine temperature. Suppose a thermistor has resistances of 8.4 Ω and 3.6 Ω at ice point and steam point respectively. Assume that the change of resistance with temperature is uniform as shown in the figure. What would be the temperature if the resistance of the of the metal wire is 5.8 Ω ?

A. 42°C
B. 46°C
C. 54°C
D. 58°C

Part C : HKDSE examination questions

42. **< HKDSE Practice Paper IA - 2 >**

In the figure below, a training pool B is located next to the main pool A. The training pool B has a smaller area and is shallower. If the pools are under the sunlight at the same time, which of the following statements about the rise in the water temperature of the two pools is correct ? Assume that the initial water temperatures of the pools are the same.



A. The water temperature of training pool B rises faster because it is shallower.
B. The water temperature of training pool B rises faster because it has a smaller surface area.
C. The water temperature of main pool A rises faster because it is deeper.
D. The water temperature of main pool A rises faster because it has a larger surface area.

43. **< HKDSE Practice Paper IA - 3 >**

Peter adds 50 g of milk at 20°C to 350 g of tea at 80°C, what is the final temperature of the mixture ?

Given : Specific heat capacity of milk = 3800 J kg^{-1} °C^{-1}
Specific heat capacity of tea = 4200 J kg^{-1} °C^{-1}

A. 50.0°C
B. 72.5°C
C. 73.1°C
D. 77.4°C

34. What happens when a cup of water at room temperature is heated ?

(1) An increase in the total number of water molecules
(2) An increase in molecular size
(3) An increase in the average kinetic energy of the molecules

A. (1) only
B. (3) only
C. (1) & (2) only
D. (2) & (3) only

35. Which of the following physical properties cannot be used to measure temperature ?

A. Liquid volume
B. Resistance of metal
C. Mass
D. Gas pressure

36. The length between the 0°C mark and the 100°C mark is 20 cm. When the mercury level is 5 cm below the 100°C mark, the temperature is

A. 25°C
B. 50°C
C. 60°C
D. 75°C

37. When a mercury thermometer is immersed in melting ice, the length of the mercury thread is 2 cm. When it is put into the steam above boiling water, the length of the thread is found to be 24 cm. What is the difference between each 1°C mark on the thermometer ?

A. 0.22 cm
B. 0.24 cm
C. 2.20 cm
D. 22.0 cm

38. Heat is supplied at the same rate to equal amount of water and oil placed in similar containers. The temperature of the oil rises faster. Which of the following is the possible reason ?

A. Oil has a lower density than water.
B. Oil has a higher boiling point than water.
C. Oil has a smaller specific heat capacity than water.
D. Oil evaporates less readily than water.

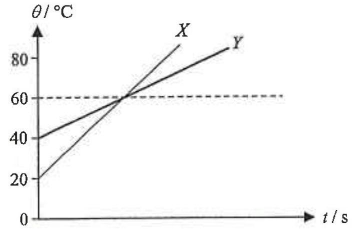
39. It takes 8 minutes to raise the temperature of 2 kg of a liquid by 40°C using a 2.5 kW heater. How long would it take to raise the temperature of 4 kg of the liquid by 20°C using a 5.0 kW heater ? (Assume no heat loss to the surroundings.)

A. 2 minutes
B. 4 minutes
C. 16 minutes
D. 32 minutes

40. A beaker contains 0.5 kg of water at 60°C. A cup containing 0.3 kg of water at 18°C is poured into the beaker. When the mixture reaches the final common temperature, 200 J of heat is lost to the surroundings. Calculate the final temperature of the mixture. Given : specific heat capacity of water is 4200 J kg^{-1} °C^{-1}.

A. 35.6°C
B. 44.2°C
C. 48.5°C
D. 54.2°C

47. **< HKDSE 2015 Paper IA - 2 >**



Two objects X and Y are heated separately by heaters of the same power. They are made of the same material. The graph shows the variation of temperature θ of X and Y with time t. What is the ratio of mass of X to that of Y ?

A. 3 : 1
B. 2 : 1
C. 1 : 2
D. 2 : 3

48. <HKDSE 2020 Paper IA-2>

An electric kettle which contains 1 kg of water at room temperature takes 168 s to heat up the water to boiling point. The kettle's rated value is '220 V, 2000 W'. Assume that all the electrical energy consumed by the kettle is transferred to the water. Which of the following statements is/are correct ?
Given: specific heat capacity of water = 4200 J kg^{-1} °C^{-1}

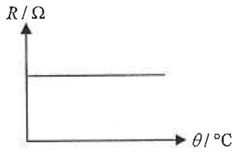
(1) The initial temperature of the water is 20 °C.
(2) The resistance of the kettle's heating element is about 24 Ω.
(3) If the electric kettle is operated with 110 V, the time taken to heat up the water to boiling point will be doubled.

A. (1) only
B. (3) only
C. (1) and (2) only
D. (1), (2) and (3)

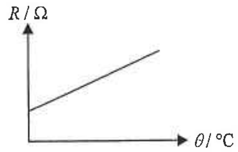
44. **< HKDSE Practice Paper IA - 1 >**

The graph below show how the electrical resistance R of three different circuit elements change with temperature θ. Which of the circuit elements can be used to measure temperature ?

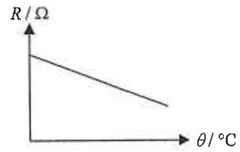
(1)



(2)



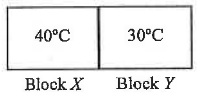
(3)



A. (1) only
B. (2) only
C. (1) & (3) only
D. (2) & (3) only

45. **< HKDSE 2012 Paper IA - 1 >**

Two metal blocks X and Y of the same mass and of initial temperatures 40°C and 30°C respectively are in good thermal contact as shown. The specific heat capacity of X is greater than that of Y. Which statements is correct when a steady state is reached ? Assume no heat loss to the surroundings.



A. The temperature of block X is higher than that of block Y.
B. Their temperature becomes the same and is lower than 35°C.
C. Their temperature becomes the same and is higher than 35°C.
D. Their temperature becomes the same is equal to 35°C.

46. **< HKDSE 2015 Paper IA - 3 >**

When two objects P and Q are in contact, heat flows from P to Q. P must have a higher

(1) temperature.
(2) internal energy.
(3) specific heat capacity.

A. (1) only
B. (3) only
C. (1) & (2) only
D. (1) & (3) only

6. B

By $E = P\,t = m\,c\,\Delta T$

$\therefore\ P\,(100) = (0.5)\,(4000)\,(70 - 10)$

$\therefore\ P = 1200$ W

7. D

At time = 300 s, the heater is still hot and still transfers heat to the water

∴ water temperature rises for a short while as shown in C and D

A short while after the heater switched off, water starts to cool down,

∴ the temperature of water drops and finally equals the initial room temperature as shown in D.

8. C

By $E = m\,c\,\Delta T$

$\therefore\ c = \dfrac{E}{m \cdot \Delta T} = \dfrac{16500}{0.5 \times 64}\ \text{J kg}^{-1}\ {}^\circ\text{C}^{-1}$

9. B

Water, with high specific heat capacity, can absorb large amount of the heat in the engine.

∴ Water is used as coolant.

10. C

By $E = m\,c\,\Delta T$

$\therefore\ \Delta T = \dfrac{E}{m \cdot c} \propto \dfrac{1}{m \cdot c}$

∴ The smallest rise in temperature corresponds to the largest product of mass and specific heat capacity.

∴ R would be the substance with the smallest rise in temperature.

11. D

× (1) Internal energy is the total energy stored in a body, heat is a process to transfer energy.

✓ (2) It is the definition of heat.

✓ (3) When a body is heated, energy is transferred to the body and its internal energy must increase.

12. D

✓ (1) Water has a high specific heat capacity to absorb heat in car engines.

✓ (2) Since water has a high specific heat capacity, its temperature change is smaller and thus coastal areas have less change of temperature while inland areas have larger change of temperature between summer and winter.

✓ (3) Since human beings contain large amount of water and water has a high specific heat capacity, therefore, body temperature changes more slowly than the surroundings.

HKEAA's Marking Scheme is prepared for the markers' reference. It should not be regarded as a set of model answers. Students and teachers who are not involved in the marking process are advised to interpret the Marking Scheme with care.

M.C. Answers

1. B	11. D	21. B	31. A	41. C
2. D	12. D	22. A	32. A	42. A
3. C	13. C	23. A	33. A	43. C
4. B	14. A	24. B	34. B	44. D
5. B	15. C	25. C	35. C	45. C
6. B	16. C	26. B	36. D	46. A
7. D	17. D	27. A	37. A	47. C
8. C	18. A	28. C	38. C	48. C
9. B	19. B	29. A	39. B	
10. C	20. C	30. A	40. B	

M.C. Solution

1. B

By $\dfrac{\theta}{100} = \dfrac{\ell - \ell_0}{\ell_{100} - \ell_0}$ $\quad\therefore\ \dfrac{\theta}{100} = \dfrac{11-2}{22-2}$ $\quad\therefore\ \theta = 45^\circ\text{C}$

2. D

By $c = \dfrac{E}{m \cdot \Delta T} \propto \dfrac{1}{m \cdot \Delta T}$

∴ The smallest specific heat capacity corresponds to the largest product of mass and rise in temperature.

∴ S would be the substance with the smallest specific heat capacity.

3. C

As heat capacity = mass × specific heat capacity ($C = m\,c$)

∴ Heat capacity depends on mass m and the material c but does not depend on shape.

4. B

× A. Same type of material (water) has the same specific heat capacity.

✓ B. Different states of the same substance have different specific heat capacities.

× C. Specific heat capacity is independent of the container

× D. Specific heat capacity is independent of the temperature

5. B

By $E = P\,t = m\,c\,\Delta T$ $\quad\therefore\ (500)\,(20) = (1)\,c\,(60 - 20)$ $\quad\therefore\ c = 250\ \text{J kg}^{-1}\ {}^\circ\text{C}^{-1}$

20. C

Since $E = mc\Delta T$

$\therefore (R_2 - R_1) = mc(47 - 21)$ $\therefore c = \dfrac{R_2 - R_1}{26m}$

21. B

Heat lost by the metal block = heat gained by water

$\therefore m_b c_b \Delta T_b = m_w c_w \Delta T_w$

$\therefore (0.8)\, c_b (100 - 38) = (0.3)(4200)(38 - 23)$

$\therefore c_b = 381 \text{ J kg}^{-1} \text{ °C}^{-1}$

22. A

By $c_b = \dfrac{m_w c_w \Delta T_w}{m_b \Delta T_b}$

✓ A. If some hot water is adhered to the metal block, ΔT_w is greater and thus c_b is higher than the true value.

× B. If some energy is lost to the surroundings, ΔT_w is smaller and thus c_b should be lower than the true value.

× C. If some energy is absorbed by the cup, ΔT_w is smaller and thus c_b should be lower than the true value.

× D. If the temperature of the metal block is still higher than 38°C when the water reaches 38°C, heat gained by the water is smaller and thus ΔT_w is smaller $\therefore$ c_b should be lower than the true value.

23. A

Heat must flow from a body of higher temperature to a body of lower temperature until they are at the same temperature.

If there is no heat flow, the two bodies must be at the same temperature.

24. B

$E = mc\Delta T = (0.5)(4200)(100 - 20) = 168\,000 \text{ J}$

$P = \dfrac{E}{t} = \dfrac{168000}{4 \times 60} = 700 \text{ W}$

25. C

By $E = Pt = mc\Delta T$

Slope $= \dfrac{\Delta T}{t} = \dfrac{P}{mc} \propto \dfrac{1}{c}$

Since R has the smallest slope, R has the highest specific heat capacity c.

26. B

✓ (1) Temperature is a measure of the degree of hotness of an object.

× (2) Internal energy depends on temperature, but also depends on mass, material and state.

✓ (3) Temperature and average kinetic energy of the molecules are inter-related.

13. C

× (1) Heater is still hot and still transfers heat to the liquid after switched off
Thus the temperature should not be taken immediately
but should wait for a short while until the liquid reaches the final temperature.

✓ (2) Covering the cup with a lid can reduce energy loss to surroundings and improve the accuracy

✓ (3) Stirring can ensure uniform temperature of the liquid

14. A

By $E = Pt = mc\Delta T$

$\therefore (100)(2 \times 60) = (0.3)(2000)(T - 23)$

$\therefore T = \left(\dfrac{100 \times 120}{0.3 \times 2000} + 23\right) \text{°C}$

15. C

By $E = Pt = mc\Delta T$

$\therefore (400)(60) = (2)\, c\, (25 - 15)$

$\therefore c = 1200 \text{ J kg}^{-1} \text{ °C}^{-1}$

16. C

✓ (1) It is the definition of internal energy.

× (2) Two bodies of different masses have different internal energy even if they are at the same temperature.

✓ (3) It is the definition of heat.

17. D

As $E = mc\Delta T$

$\therefore$ slope $= \dfrac{E}{\Delta T} = mc \propto c$

As slope of X > slope of Y = slope of Z

$\therefore c_X > c_Y = c_Z$.

18. A

× (1) Internal energy also depends on mass of the body and the type of material.

× (2) Since P and Q are two different objects, they should have different specific heat capacity.

✓ (3) Heat would always flow from a body of high temperature to another body of lower temperature.

19. B

By $E = Pt = mc\Delta T$

$\therefore t = \dfrac{m \cdot c \cdot \Delta T}{P} \propto c \cdot \Delta T$

where ΔT is the difference of temperatures between the boiling point and 20°C

Among the four liquids, Q has the smallest $c\,\Delta T$, thus Q boils first.

33. A

✓ (1) Heat capacity = mass × specific heat capacity

× (2) Heat capacity is independent of the temperature of the object

× (3) Heat capacity is independent of the container

34. B

× (1) Total number of water molecules should remain unchanged.

× (2) Molecular size would not increase when temperature is increased.

✓ (3) When water is heated, its temperature increases ; thus the average K.E. of water molecules increases.

35. C

✓ A. The expansion of liquid causes the liquid volume to increase with temperature

✓ B. Resistance of metal increases with temperature.

× C. Mass remains constant when temperature increases.

✓ D. Gas pressure in a fixed container increases with temperature.

36. D

If the mercury level is 5 cm below 100°C mark, then it is 15 cm above 0°C mark.

By $\frac{\theta}{100} = \frac{\ell - \ell_0}{\ell_{100} - \ell_0}$ $\therefore$ $\frac{\theta}{100} = \frac{15}{20}$ $\therefore$ $\theta = 75°C$

37. A

Length of mercury thread between 0°C mark and 100°C mark = 24 – 2 = 22 cm

Length of mercury thread between each 1°C mark = $\frac{22}{100}$ = 0.22 cm

38. C

By $E = m\,c\,\Delta T$

a smaller value of specific heat capacity c causes a greater rise of temperature ΔT.

39. B

By $E = P\,t = m\,c\,\Delta T$

$t = \frac{m\,c\,\Delta T}{P} \propto \frac{m\,\Delta T}{P}$ $\therefore$ $\frac{t_1}{t_2} = \frac{m_1}{m_2} \cdot \frac{\Delta T_1}{\Delta T_2} \cdot \frac{P_2}{P_1}$

$\therefore$ $\frac{(8)}{t_2} = \frac{(2)}{(4)} \cdot \frac{(40)}{(20)} \cdot \frac{(5.0)}{(2.5)}$ $\therefore$ $t_2 = 4$ minutes

40. B

Heat lost by the hot water = heat gained by the cold water + heat lost to surroundings

$\therefore$ $(0.5)(4200)(60 - \theta) = (0.3)(4200)(\theta - 18) + (200)$ $\therefore$ $\theta = 44.2°C$

27. A

① $E = P\,t = (100)(3 \times 60) = 18000$ J

② $E = m\,c\,\Delta T = (0.5)(4200)(30 - 25) = 10500$ J

③ Energy loss = 18000 – 10500 = 7500 J

28. C

× (1) Internal energy depends on the mass of water,
water of greater mass contains more internal energy.

✓ (2) Internal energy depends on temperature,
water of higher temperature contains more internal energy.

✓ (3) Internal energy depends on the state,
water at liquid state contains more internal energy than that in solid state.

29. A

✓ (1) After a long time, the temperature of the water should be same as the environmental temperature,
i.e. temperature inside the refrigerator, thus their temperatures should be equal.

✓ (2) Average kinetic energy depends on the temperature, thus their average *KE* is equal.

× (3) Total *PE* depends on the state, and also depends on the number of molecules,
the bottle containing greater mass of water has more molecules, thus it has more total *PE*.

30. A

✓ (1) By $E = P\,t = C\,\Delta T$ $\therefore$ slope = $\frac{\Delta T}{t} = \frac{P}{C} \propto \frac{1}{C}$
Object X has greater slope, thus X has smaller heat capacity C.

✓ (2) If they are made of the same material, they have the same specific heat capacity c.
By $C = m\,c \propto m$ As X has the smaller C, X has the smaller mass m.

× (3) As the two objects may have different masses, their relation of specific heat capacity c cannot be known.

31. A

✓ (1) $C = \frac{E}{\Delta T}$ $\therefore$ $C_X = \frac{24000}{20} = 1200$ J °C^{-1} and $C_Y = \frac{18000}{25} = 720$ J °C^{-1} $\therefore$ $C_X > C_Y$

✓ (2) $c = \frac{E}{m \cdot \Delta T}$ $\therefore$ $c_X = \frac{24000}{0.3 \times 20} = 4000$ J kg^{-1} °C^{-1} and $c_Y = \frac{18000}{0.2 \times 25} = 3600$ J kg^{-1} °C^{-1} $\therefore$ $c_X > c_Y$

× (3) Heat capacity depends on the mass. If the mass is doubled, the heat capacity will also be doubled.

32. A

✓ (1) Mercury expands uniformly when temperature rises.

✓ (2) Mercury remains as liquid at least from 0°C to 100°C which is suitable for our daily application.

× (3) Mercury is opaque.

47. C

By $P\,t = m\,c\,\Delta\theta$

Since the two objects are made of the same material, they have the same specific heat capacity c.

For the same time t and same power P,

$m_X : m_Y = \Delta\theta_Y : \Delta\theta_X = (60 - 40) : (60 - 20) = 20 : 40 = 1 : 2$

41. C

$\theta = \dfrac{5.8 - 8.4}{3.6 - 8.4} \times 100 = 54°C$

42. A

✓ A. Since pool *B* is shallower, the mass of water is less, by $E = m\,c\,\Delta T$, the rise of temperature is faster.

× B. Pool *B* absorbs less solar energy due to the smaller surface area, it is not the reason for the faster rise of temperature.

× C. Since pool *A* is deeper, the mass of water is more, thus the rise of temperature should not be faster.

× D. Although pool *A* absorbs more solar energy due to larger surface area, larger surface area also implies more mass, thus the rise of temperature cannot be faster.

43. C

By conservation of energy and assume no heat lost to the container and surrounding air.

Heat gained by the milk = heat lost by the tea

$(0.050)\,(3800)\,(\theta - 20) = (0.350)\,(4200)\,(80 - \theta)$

$\therefore\ \theta = 73.1°C$

44. D

× (1) Since the resistance is constant and does not change with the temperature, it is not suitable.

✓ (2) As the resistance increases with the temperature, it is suitable to be used to measure temperature.

✓ (3) As the resistance decreases with the temperature, it is suitable to be used to measure temperature.

45. C

At steady state, the temperature must be the same.

By conservation of energy and assume no heat lost to the surroundings.

Heat lost by block X = heat gained by block Y

$m\,c_X\,\Delta T_X = m\,c_Y\,\Delta T_Y$

$\therefore\ c_X > c_Y \qquad \therefore\ \Delta T_X < \Delta T_Y$

Thus, the final temperature should be closer to 40°C, that is, higher than 35°C.

46. A

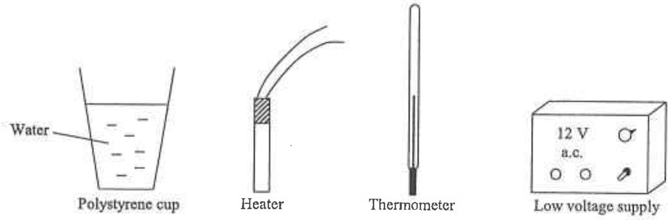
✓ (1) Heat must flow from object of higher temperature to that of lower temperature. Thus, temperature of *P* must be higher than that of *Q*.

× (2) A body may have less internal energy than another body but higher temperature. Thus, no conclusion can be drawn about the internal energy of *P* and *Q*.

× (3) The specific heat capacity depends on the material. Different specific heat capacity would not affect the direction of flow of heat.

2. < HKCE 1986 Paper I - 4 >

The below figure shows the apparatus which may be used to measure the specific heat capacity of water.



(a) Draw a simple diagram to show how the apparatus can be set up for the experiment. (3 marks)

(b) The following are readings taken in the experiment : (7 marks)

The rating of the heater	=	12 V 40 W
Mass of water used	=	200 g
Initial temperature of the water	=	25.1°C
Final temperature of the water	=	53.2°C
Time taken to heat up the water	=	10 minutes

(i) Calculate the specific heat capacity of water as measured from the experiment, given that the water is well-stirred throughout the experiment.

(ii) Give two reasons why a polystyrene cup should be used in the experiment.

(iii) Why should the water be stirred throughout the experiment ?

(c) Describe, with the aid of a diagram, a method to check whether the power output of the heater is 40 W. Show how the actual power output of the heater can be calculated. (5 marks)

Diagram

The following list of formulae may be found useful :

Energy transfer during heating or cooling $E = m c \Delta T$

Part A : HKCE examination questions

1. < HKCE 1984 Paper I - 4 >

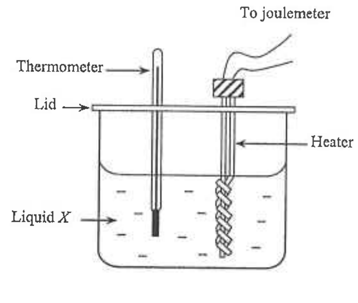


Figure 1

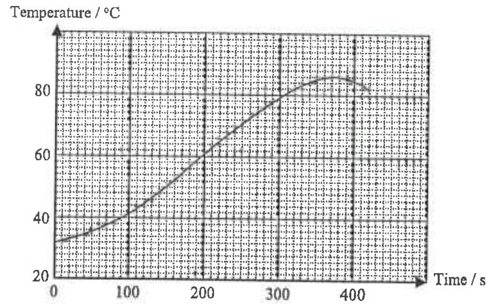


Figure 2

The figure 1 above shows an experimental set-up to find the specific heat capacity of a liquid. The liquid X, contained in the plastic cup, is heated from room temperature by an immersion heater. The energy transferred through the heater is measured by a joulemeter. The heater is switched on for 330 s and then switched off. The variation of the temperature of the liquid X with time is plotted in a graph shown in figure 2.

(a) After the heater is switched off, the temperature of the liquid rises for a while and then falls. Explain why. (3 marks)

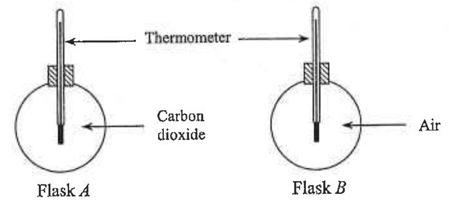
(b) What is the maximum increase in the temperature of liquid X in this experiment ? (2 marks)

(c) The initial and final readings of the joulemeter are 74050 J and 83770 J respectively. The mass of the liquid X is 0.2 kg. What is the specific heat capacity of the liquid, as found from this experiment ? Assume the heat capacity of the apparatus and the heat lost to the surroundings are negligible. (4 marks)

(d) Although the plastic cup is made of poor conducting material, some energy is still lost to the surroundings. Should the result obtained in (c) be higher or lower than the true value of the specific heat capacity of the liquid X ? Explain briefly. (3 marks)

(e) If a student forgets to cover the plastic cup with the lid, would he expect the maximum increase in temperature to be higher than, equal to or lower than the value obtained in (b) ? Explain briefly. (3 marks)

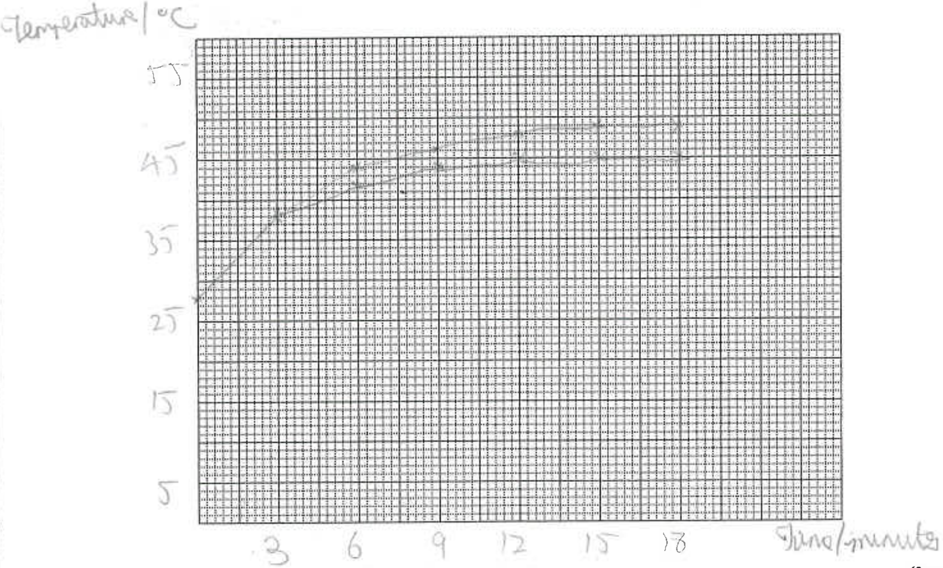
4. < HKCE 1991 Paper I - 5 >



The figure above shows the apparatus of an experiment to study the absorption of solar energy by gases. Identical flasks *A* and *B* are filled with carbon dioxide and air respectively. They are placed under sunlight and their temperatures are taken at 3-minute intervals. The results are as follows :

Time / minutes	0	3	6	9	12	15	18
Temperature in *A* / °C	28.0	38.4	44.0	46.2	47.8	48.8	48.8
Temperature in *B* / °C	28.0	37.7	41.8	43.7	45.2	46.0	46.0

(a) Using a scale that 2 cm represents 5°C and 2 cm represents 3 minutes, plot the temperature-time graphs for carbon dioxide and air on the same graph paper. (5 marks)



(b) Why does each of the gases reach a steady temperature ? (2 marks)

(c) The mass of carbon dioxide in flask *A* is 0.00196 kg and the mass of air in flask *B* is 0.00125 kg. The specific heat capacities of carbon dioxide and air are 640 J kg^{-1} °C^{-1} and 740 J kg^{-1} °C^{-1} respectively. Which flask of gas gains more energy to reach its steady temperature ? Show your calculations. (5 marks)

3. < HKCE 1987 Paper I - 6 >

The specific heat capacity of water is 4200 J kg^{-1} °C^{-1}.

(a) What does this statement mean ? (2 marks)

(b) Describe briefly, with the aid of a diagram, an experiment to measure the specific heat capacity of water. (5 marks)

Diagram

(c) A kettle with 1.6 kg of water is placed on top of an electric heater at 1000 W. It takes 14 minutes for the temperature of the water to increase from 20°C to 100°C.

(i) Find

(I) the energy released by the heater, and

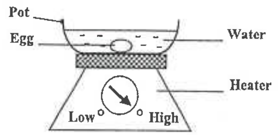
(II) the energy absorbed by the water

during that time. (4 marks)

(ii) Give TWO reasons to account for the difference of the values you obtained in (i) and (ii). (2 marks)

(d) The specific heat capacity of water is higher than most of the other liquids. Name TWO practical importance of this in daily life. (2 marks)

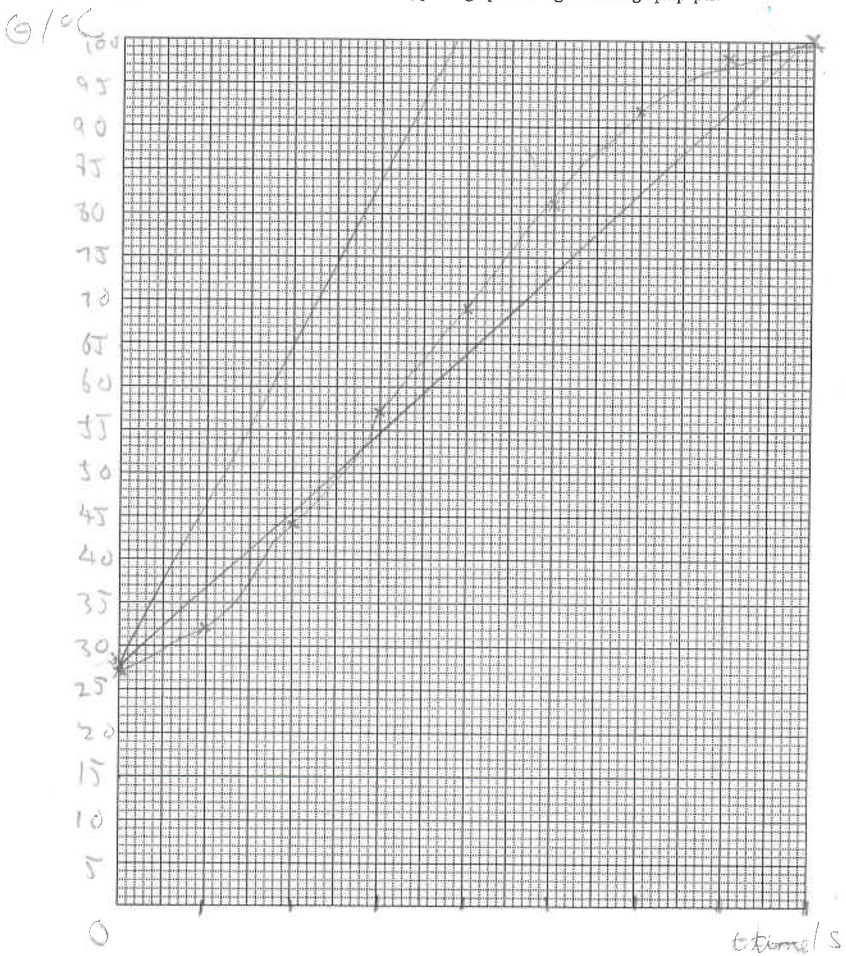
6. **< HKCE 2000 Paper I - 8 >**



An electric heater has two settings : 'Low' and 'High'. The power output of the heater is 1400 W at the 'Low' setting and 2200 W at the 'High' setting. The heater is used to cook an egg. The egg is first put into a pot containing 1 kg of water and the heater is operated at the 'High' setting. (See the above figure.) The temperature of the water is recorded every 30 s and the following results are obtained :

Time t / s	0	30	60	90	120	150	180	210	240
Temperature θ / °C	27	32	44	57	69	81	92	98	100

(a) Using a scale of 1 cm to 5°C and 1 cm to 15 s, plot a graph of θ against t on graph paper. (4 marks)



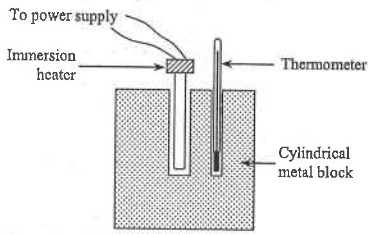
4. (d) Each year the amount of carbon dioxide in the atmosphere is increased by billions of tons.

(i) Suggest a possible effect on the mean temperature of the Earth. (1 mark)

(ii) Suggest two methods to reduce the amount of carbon dioxide in the atmosphere. (2 marks)

5. **< HKCE 1992 Paper I - 4 >**

A student uses the experimental set-up shown in the below figure to find the specific heat capacity of a metal. The cylindrical metal block is heated by an immersion heater of unknown power. The following results are obtained:



Mass of metal block	=	1 kg
Initial temperature of metal block	=	29°C
Final temperature of metal block	=	41°C
Energy supplied by the heater	=	12300 J

(a) Describe, with the help of a diagram, a method to measure the energy supplied by the heater. (4 marks)

Diagram

(b) Calculate the specific heat capacity of the metal. (2 marks)

(c) The value obtained in (b) is found to be higher than the actual specific heat capacity of the metal. Suggest a reason for this and explain your answer briefly. (3 marks)

(d) Suggest TWO improvements on the set-up to increase the accuracy of the experiment. (2 marks)

(e) Is the above method suitable for finding the specific heat capacity of wood ? Explain briefly. (3 marks)

6. (b) (i) Find the energy supplied by the heater from $t = 0$ to $t = 240$ s. (2 marks)

(ii) Find the energy absorbed by the water from $t = 0$ to $t = 240$ s.
(Note : Specific heat capacity of water = 4200 J kg^{-1} °C^{-1}.) (2 marks)

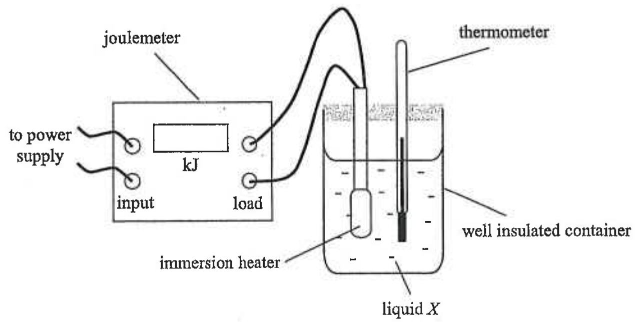
(iii) State **two** reasons to account for the difference between your answers in (i) and (ii). (2 marks)

(c) After the water boils, the heater is turned to the 'Low' setting and the water still boils afterwards. A student argues that this will lengthen the time required to cook the egg. Do you agree ? Explain your answer. (3 marks)

(d) If less water is used in the above cooking process, on the graph in (a), draw the graph of θ against t you expect to obtain. (2 marks)

7. **< HKCE 2008 Paper I - 4 >**

A student performs an experiment with the setup in the below Figure to measure the specific heat capacity of a liquid X. The joulemeter in the figure is used to measure energy consumed by the immersion heater.

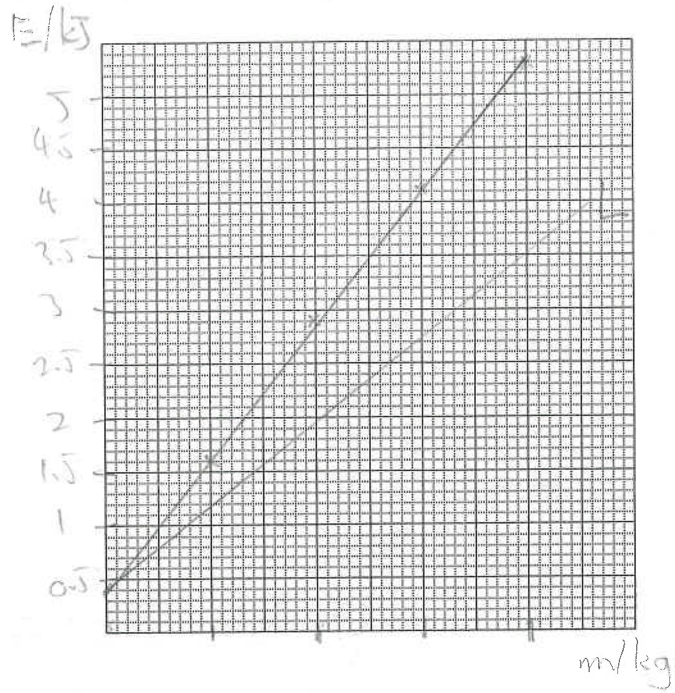


The increase in the reading of the joulemeter (E) for an increase of temperature of 10°C for different mass (m) of liquid X is recorded in the Table below.

E / kJ	1.6	2.9	4.1	5.3
m / kg	0.05	0.10	0.15	0.20

(a) State the importance of using a "well insulated" container in the experiment. (1 mark)

7. (b) (i) Plot a graph of E against m in the following figure. A scale of 1 cm to 0.5 kJ and 0.025 kg is used. (4 marks)



(ii) Using the graph plotted in (b)(i), find the specific heat capacity of liquid X. (3 marks)

(iii) Estimate the heat absorbed by the apparatus. (1 mark)

(iv) If the experiment is repeated with liquid Y with a smaller specific heat capacity than liquid X and the increase in temperature is also 10°C, sketch a graph of E against m you would expect to obtain in the above figure, and label it as L. (2 marks)

9. **< HKDSE 2013 Paper IB - 1 >**

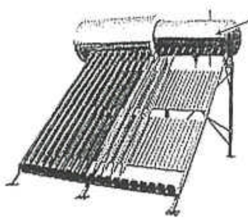


Figure 1

A solar water heater shown in Figure 1 is installed on the rooftop of a house. During the day, the heater heats up 1.5 m^3 of water to 80°C. At night, the hot water in the storage tank is circulated to the radiators (see Figure 2) in different rooms of the house to keep the rooms warm.

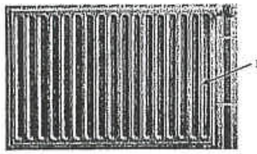


Figure 2

Given : density of water = 1000 kg m^{-3}

specific heat capacity of water = 4200 J kg^{-1} $°C^{-1}$

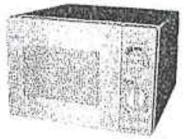
(a) Given that 15% of the energy is lost during the transfer of water, how much heat can be released from the system to the rooms when the water temperature drops to 60°C ? (3 marks)

(b) Given that during night time the radiators maintain an average output power of 4.5 kW, how long can the radiators maintain this average power until the water temperature in the system drops to 60°C ? Give your answer in hours. (2 marks)

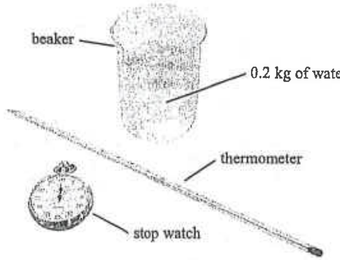
(c) The rate of heat released by the solar water heating system during the time period calculated in (b) is in fact not constant and gradually drops. Explain why this is so. (1 mark)

Part B : HKDSE examination questions

8. **< HKDSE Sample Paper IB - 9 >**



The Figure above shows a microwave oven. Mary wants to conduct an experiment to estimate the useful output power of the oven. She is provided with the apparatus and material shown in the Figure below.



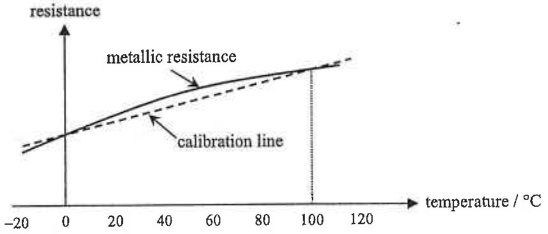
(a) Describe how Mary should conduct the experiment. Specify all measurements that Mary has to take. State **EITHER** one precaution taken **OR** one assumption made when conducting this experiment. Write down an equation for calculating the useful output power. (5 marks)

(b) The value obtained by Mary is found to be smaller than the specified power of the oven. Suggest one possible reason to account for this difference. (1 mark)

(c) Explain whether increasing the mass of water used in the experiment would improve the accuracy of the experiment. (1 mark)

11. < HKDSE 2015 Paper IB - 1 >

A metallic resistance thermometer is calibrated at standard atmospheric pressure for the melting point of ice and the steam point of boiling water. The dotted calibration line in the figure below represents how the resistance of the thermometer varies with temperature if a linear resistance-temperature relationship is assumed. The solid curve shows how the resistance of the thermometer actually varies with temperature. The deviation of the curve from linearity has been exaggerated in the figure.



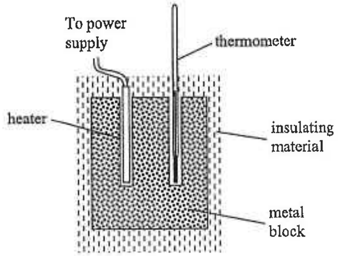
(a) (i) Using the resistances at the calibration points tabulated below, calculate the expected resistance at 60°C if the resistance varies linearly with temperature. (2 marks)

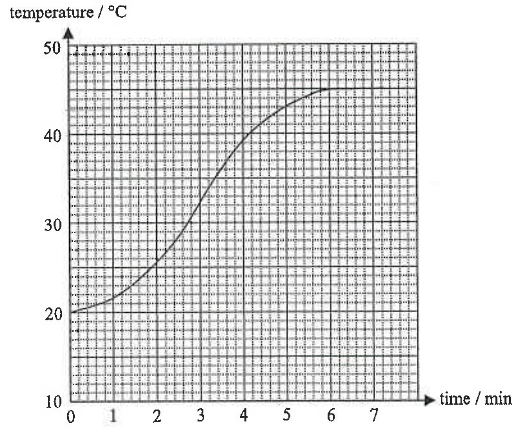
temperature / °C	resistance / Ω
0	102.00
100	140.51

(ii) Now if the resistance of the resistance thermometer is the value found in (a) (i), is the actual temperature higher than, lower than or equal to 60°C ? (1 mark)

(b) In an experiment to determine the specific heat capacity of water c_w, Peter used this calibrated resistance thermometer to measure the temperature of water being heated from 0°C to 60°C. Heating was stopped when this thermometer's resistance reached the value found in (a) (i). Assuming negligible heat exchange with the surroundings, no error in measuring the energy supplied and the mass of water, explain whether the experimental value of c_w found is higher than, lower than or the same as the actual value. (2 marks)

10. < HKDSE 2014 Paper IB - 1 >





The above figure shows an experimental set-up to find the specific heat capacity of a metal. The metal block is wrapped by insulating material. A heater is connected to a power supply. It is switched on when the temperature of the metal block is 20°C and then switched off when the temperature reaches 43°C. The graph shows the variation of the temperature of the metal block with time.

(a) Use the graph to find the duration time that the heater is switched on. (1 mark)

(b) After the heater is switched off, the temperature of the metal block continues to rise for a while. Explain why. (1 mark)

(c) Given : mass of the metal block = 0.80 kg ; heater voltage = 12 V ; heater current = 4.0 A.

(i) By considering the maximum temperature rise of the metal block, calculate the specific heat capacity of the metal as found from the experiment. (2 marks)

(ii) Would your result be the same, higher, or lower than the actual value of the specific heat capacity of the metal ? Explain. (2 marks)

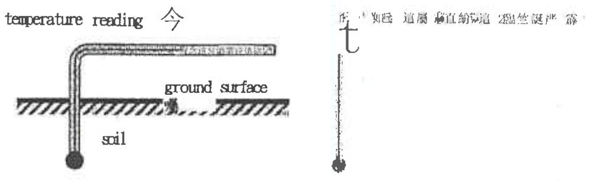
(d) This method is not suitable for measuring the specific heat capacity of a glass block. Explain. (1 mark)

13 < HKDSE 2017 Paper 1B - 1 >

Read the following passage about soil thermometer and answer the questions that follow.

The temperature of soil changes with depth, and this information is important to farmers and scientists. To measure soil temperatures at depths close to the ground surface, the bulb of a thermometer is buried in the soil. The stem of the thermometer is bent 90° for easy reading. Figure 1a is a schematic diagram and Figure 1b shows a photo of a soil thermometer.

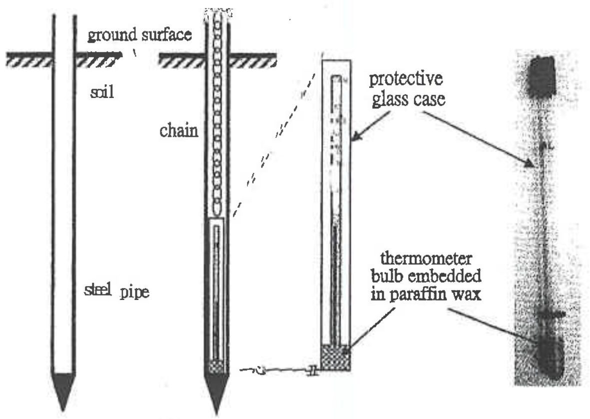
Figure 1



(a) (b)

For depths greater than 30 cm, a steel pipe is driven into the soil (Figure 2a); and a liquid-in-glass thermometer with a protective glass case is lowered into the steel pipe (Figure 2b). The bulb of the thermometer is embedded in paraffin wax (Figure 2c). To read the temperature, the thermometer is lifted out of the steel pipe by pulling the chain.

Figure 2



(a) (b) (c)

(a) As shown in Figure 1b, the bulb of the soil thermometer is very large compared to those of common thermometers. Suggest a reason for this design. (1 mark)

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12 < HKDSE 2016 Paper 1B - 1 >

The following experimental items are provided for estimating the specific heat capacity of bronze c_B.

- a bronze sphere of mass 0.80 kg hung with a thread at room temperature T_o
- a polystyrene cup containing 0.50 kg of water at room temperature T_o
- a water bath maintained at 80 °C
- a thermometer
- a stirrer
- a towel

(a) Describe the procedures of the experiment and state TWO experimental precautions to be taken. Write down an equation for finding c_B.

Given: specific heat capacity of water = 4200 J kg^{-1} °C^{-1} (6 marks)

(b) The value of c_B found in the experiment in (a) is lower than the actual value. Explain. (2 marks)

HKEAA's Marking Scheme is prepared for the markers' reference. It should not be regarded as a set of model answers. Students and teachers who are not involved in the marking process are advised to interpret the Marking Scheme with care.

Question Solution

1. (a) After switching off, the heater is still hot. [1]

Energy continues to transfer to the liquid. [1]

After a while, heat is lost to the surroundings, thus temperature drops. [1]

(b) Maximum increase in temperature = 86 – 32 [1]

= 54°C [1]

(c) $E = m\,c\,\Delta T$ [1]

(83770 – 74050) = (0.2) c (54) [2]

$\therefore\ c$ = 900 J kg^{-1} °C^{-1} [1]

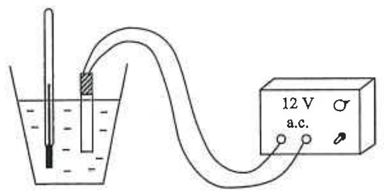
(d) Higher [1]

More energy is required to raise the same temperature of the liquid. [2]

(e) Smaller [1]

More energy is lost to surroundings [2]

2. (a)



< heater immersed in water > [1]

< heater connected to power supply > [1]

< thermometer immersed in water > [1]

(b) (i) Heat transferred to water :

E = 40 × 60 × 10 = 24000 J [1]

Increase in temperature :

ΔT = 53.2 – 25.1 = 28.1°C [1]

By $E = m\,c\,\Delta T$ [1]

$\therefore$ (24000) = (0.2) c (28.1)

$\therefore\ c$ = 4270 J kg^{-1} °C^{-1} [1]

13. (b) On a certain morning, the air temperature is 15°C. An observer takes a measurement of the soil temperature at 1 m deep. The thermometer reading is 20°C. It is given that the mass of the paraffin wax enclosing the thermometer bulb is 0.015 kg, and the specific heat capacity of paraffin wax is 2.9 × 103 J kg^{-1} °C^{-1}.

(i) Calculate the energy loss of the paraffin wax as it cools down to the air temperature. (2 marks)

(ii) It is known that the paraffin wax enclosing the bulb of the thermometer gains or loses energy at a constant rate of 0.5 J s^{-1}, estimate the time taken for the paraffin wax to reach the air temperature after the thermometer is lifted out of the soil. (2 marks)

(iii) If there is no paraffin wax enclosing the bulb of the thermometer, explain how the thermometer reading as recorded by the observer is affected. (2 marks)

14 < HKDSE 2019 Paper 1B -1 >

(a) An insulated container of negligible heat capacity contains 1.5 kg of tea at a temperature of 60 °C.

(i) What mass of ice at 0 °C should be added to the tea so that the final temperature of the mixture is lowered to 10 °C ? Assume that the specific heat capacity of tea is the same as that of water. (3 marks)
Given: specific latent heat of fusion of ice = 3.34×10^5 J kg^{-1}
specific heat capacity of water = 4200 J kg^{-1} °C^{-1}

(ii) Suggest **ONE** modification to this bag that would enhance its ability to keep things stored inside at a low temperature. (1 mark)

15. < HKDSE 2020 Paper 1B -1 >

In a restaurant, 'wontons in soup' is prepared by putting 5 pieces of cooked wonton at 4 °C into a bowl with 0.60 kg of soup at temperature 96 °C.
Given: average mass of each piece of wonton = 0.02 kg
specific heat capacity of wonton = 3300 J kg^{-1} °C^{-1}
specific heat capacity of soup = 4200 J kg^{-1} °C^{-1}

(a) Find the final temperature of the mixture. Assume that the heat capacity of the bowl and the heat loss to the surroundings are negligible. (2 marks)

(b) The soup in (a) is taken from a metallic container of heat capacity 2000 J °C^{-1} containing 16 kg of soup maintained at 96 °C by an immersion heater.

(i) Why does that energy have to be supplied by the heater to keep the soup at 96 °C ? (1 mark)

(ii) A student used the following method to find the heater's operating power P: remove the heater from the container and record the temperature of the 16 kg of soup after 10 minutes. It is found that the temperature has dropped 9 °C. Estimate P. (3 marks)

(iii) If the student repeats the measurement after another 10 minutes, would the corresponding temperature drop be larger than, equal to or smaller than 9 °C ? Explain. (2 marks)

3. (c) (i) (II) $E = m c \Delta T$

$= (1.6) \times (4200) \times (100 - 20)$ [1]

$= 537\ 600$ J [1]

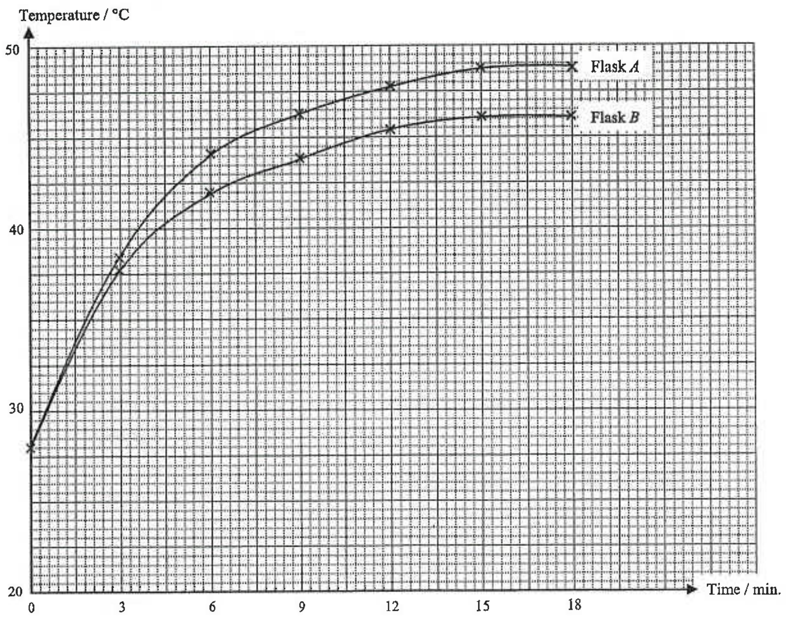
(ii) ① There is heat lost to surrounding air. [1]

② Some heat is used to heat up the kettle. [1]

(d) ① Water can be used as coolant in motor car. [1]

② Water causes the temperature of the sea to change much more slowly than that of the land.
Thus the coastal areas have relatively cooler summer and warmer winters than inland areas. [1]

4. (a)



< Correct scales > [1]

< Correct labelled axes with units > [1]

< Correct points for the curve of flask *A* > [1]

< Correct points for the curve of flask *B* > [1]

< 2 smooth curves fitted to the points > [1]

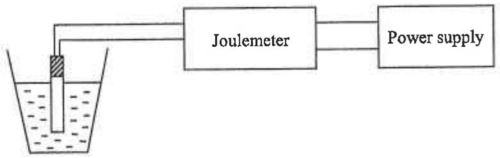
(b) The rate of heat lost by the gas to the surroundings [1]
is just equal to the rate of heat absorption from the sun. [1]

2. (b) (ii) Energy absorbed by the polystyrene cup is small since its heat capacity is small. [1]

Energy lost to the surroundings is small since polystyrene is a poor conductor of heat. [1]

(iii) To ensure that the temperature of water is uniform. [1]

(c)



[1]

The heater is connected to the power supply through a joulemeter. [1]

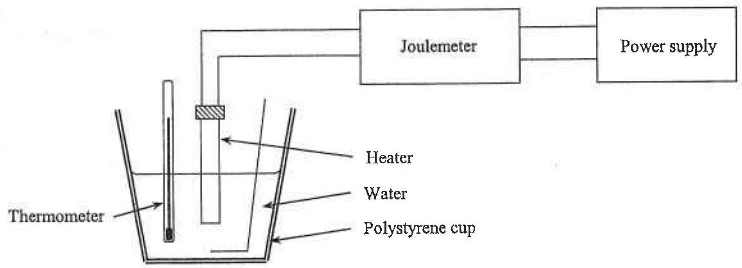
The energy given to the heater E is found by recording the initial and final readings of the joulemeter. [1]

The time taken t is found by a stop-watch. [1]

The power output of the heater is found by $P = \dfrac{E}{t}$ [1]

3. (a) It means that the energy needed to increase the temperature of 1 kg of water [1]
through 1°C is 4200 J. [1]

(b)



[1]

(b) Put known mass of water, m, into a polystyrene cup and then put the heater and thermometer into the water. [1]

The heater is then connected to the power supply through a joulemeter
and the energy E given out from the heater is recorded. [1]

The increase of temperature ΔT is recorded by using the thermometer. [1]

The specific heat capacity of water is then found by $c = \dfrac{E}{m \cdot \Delta T}$ [1]

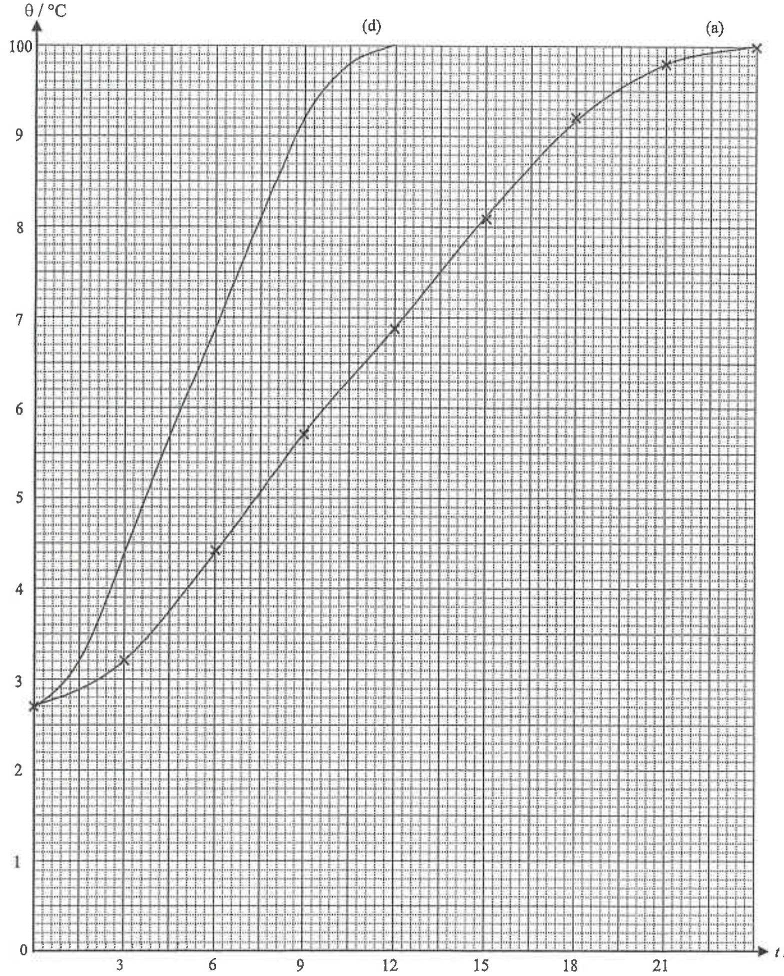
(c) (i) (I) $E = P t$

$= (1000) \times (14 \times 60)$ [1]

$= 840\ 000$ J [1]

5. (e) No. [1]
Wood is a poor conductor of heat. (**OR** Wood is not a good conductor of heat.) [1]
The wood cannot have uniform temperature throughout the wood. [1]
(**OR** Different parts of the wood would have different temperatures. [1]

6. (a)



< Labelled axes with units > [1]
< Correct scales > [1]
< Correct points plotted > [1]
< Correct curve > [1]

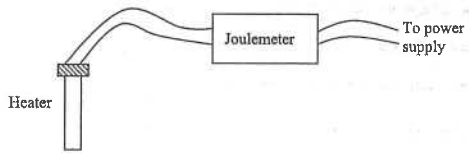
4. (c) Temperature rise of flask A = 48.8 − 28.0 = 20.8°C [1]
Energy absorbed by carbon dioxide in flask A = $m\,c\,\Delta T$
= (0.00196) × (640) × (20.8) [1]
= 26.1 J [1]
Energy absorbed by air in flask B = (0.00125) × (740) × (46.0 − 28.0) = 16.7 J [1]
∴ Flask A absorbs more energy [1]

(d) (i) Temperature rises. [1]

(ii) ① Plant more trees. [1]
OR
Stop deforestation. [1]

② Any **ONE** of the followings : [1]
- ✱ Use less fossil fuels.
- ✱ Use alternate sources of energy.
- ✱ Save electricity.
- ✱ Use less private cars.

5. (a) Connect a joulemeter to the heater from the power supply. [1]
Measure the initial and final readings of the joulemeter. [1]
The difference of the readings is the energy supplied by the heater. [1]



[1]

(b) By $E = m\,c\,\Delta T$ [1]
∴ (12300) = (1) c (41 − 29)
∴ c = 1025 J kg^{-1} °C^{-1} [1]

(c) There is heat lost to surroundings, [1]
so the energy supplied by the heater is greater than the actual energy absorbed by the metal. [2]
OR
There is heat lost to surroundings, [1]
so the temperature rise of the block is smaller than that if all the energy supplied is absorbed by the metal. [2]

(d) ① Surround the metal block with insulating material. [1]
② Put some oil in the holes to ensure good thermal contact between the heater, thermometer and the metal. [1]

7. (b) (i) < Two axes labelled with correct units > [1]
< Correct scales used > [1]
< Points correctly plotted > [1]
< Best fitted line drawn > [1]

(ii) Slope of the straight line $= \dfrac{(5.3-0.4)\times10^3}{0.20} = 24500$ [1]

By $E = m\,c\,\Delta T + E_{app}$ [1]

$\therefore\ E = c\,\Delta T\cdot m + E_{app}$ (compared with $y = m\,x + c$)

$\therefore$ slope $= c\,\Delta T$

$\therefore$ $(24500) = c\,(10)$

$\therefore\ c = 2450\ \text{J kg}^{-1}\ {}^\circ\text{C}^{-1}$ < accept 2300 to 2600 J kg^{-1} °C^{-1} > [1]

(iii) Heat absorbed by the apparatus = y-intercept
= 0.4 kJ < accept 0.2 to 0.6 kJ > [1]

(iv) < Same y-intercept > [1]
< Straight line with slope smaller as c is smaller, slope $= c\,\Delta T$ > [1]

8. (a) Put the thermometer into the water to measure its initial temperature T_1. [1]
Put the beaker of water into the oven and turn on the oven. [1]
Use the stop watch to record the time of heating t. [1]
Take out the beaker of water from the oven.
Put the thermometer into the water to measure its final temperature T_2.

Precautions / assumptions : (Any **ONE** of the followings) [1]

* ∗ Do not use the thermometer to stir the water.
* ∗ The heat capacity of the beaker is negligible compared with that of water.
* ∗ The heat lost to the surroundings is negligible.
* ∗ The energy given out by the microwaves is completely absorbed by the water.

< Use a stirrer to well stir the water is not acceptable, as no stirrer is provided >

Output power $= \dfrac{(0.2)\times c\times(T_2-T_1)}{t}$ [1]
where c is the specific heat capacity of water

(b) Some energy is absorbed by the beaker. **OR** Some energy is lost to the surrounding air. [1]

(c) The percentage of energy lost would be smaller if larger quantity of water were used. [1]
This measure would improve the accuracy of the experiment.

6. (b) (i) $E = P\times t = 2200\times240$ [1]
$= 528000\ \text{J}$ [1]

(ii) $E = m\,c\,\Delta T = (1)\times(4200)\times(100-27)$ [1]
$= 306600\ \text{J}$ [1]

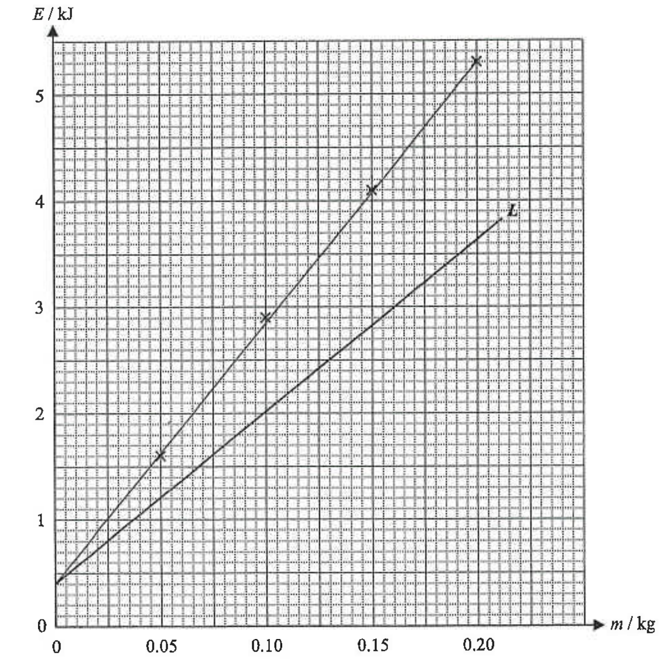
(iii) Any **TWO** of the following : [2]
* ∗ Some energy is lost to the surrounding.
* ∗ Some energy is absorbed by the egg.
* ∗ Some energy is absorbed by the pot.

(c) No, the time would not be lengthened. [1]
As the temperature of water remains at 100°C, [1]
the rate of energy absorbed by the egg remains unchanged. [1]

(d) < The curve has a steeper slope than (a) > [1]
< The curve reaches 100°C eventually > [1]

7. (a) To reduce the heat lost to the surroundings. [1]

(b) (i)



12. (a) Put the sphere into the water bath for a few minutes. [1]
Transfer the sphere into the polystyrene cup of water. [1]
Measure the final temperature T_f of the water with a thermometer. [1]
By $(0.80) \times c_b \times (80 - T_f) = (0.50) \times (4200) \times (T_f - T_o)$ [1]

$\therefore\ c_b = 2625 \times \dfrac{T_f - T_o}{80 - T_f}$

Precautions :

* Dry the sphere with the towel quickly before putting it into the cup. [1]
* Stir the water to ensure uniform temperature of water. [1]

(b) Any **ONE** of the followings : [1]

* Some heat is lost during the transfer
* Some heat is lost during the drying of the sphere
* Some heat is lost to the apparatus (thermometer, stirrer or cup)
* The temperature of the sphere is still higher than T_f when this final temperature is measured

Thus, the temperature rise of water in the cup is lower than it should be. [1]

13. (a) A large bulb increases the sensitivity of the thermometer. [1]

(b) (i) $E = m\,c\,\Delta T$
$= (0.015) \times (2.9 \times 10^3) \times (20 - 15)$ [1]
$= 217.5$ J <accept 218 J> [1]

(ii) By $E = P\,t$
$\therefore\ (217.5) = (0.5)\,t$ [1]
$\therefore\ t = 435$ s <accept 436 s> [1]

(iii) The thermometer would cool down quickly when it is in direct contact with the cooler air. [1]
The temperature reading would be less than the actual soil temperature. [1]

9. (a) $m = \rho V = 1000 \times 1.5 = 1500$ kg [1]
$E = m\,c\,\Delta T \times (1 - 15\%)$ [1]
$= (1500)\,(4200)\,(80 - 60) \times (1 - 15\%)$
$= 1.07 \times 10^8$ J [1]

(b) $E = P\,t$
$(1.07 \times 10^8) = (4.5 \times 10^3)\,t$ [1]
$\therefore\ t = 23778$ s $= 6.60$ hours <accept 6.61 hours> [1]

(c) The rate of heat transfer drops as the water temperature drops. [1]
OR
The rate of heat transfer drops as the temperature difference drops. [1]

10. (a) Time = 5 minutes <accept 300 s> [1]

(b) When the heater is switch off, its temperature is still higher than the metal. [1]

(c) (i) $P = V I = (12)\,(4.0) = 48$ W [1]
By $P\,t = m\,c\,\Delta T$
$\therefore\ (48)\,(5 \times 60) = (0.80)\,c\,(45 - 20)$
$\therefore\ c = 720$ J kg^{-1} °C^{-1} [1]

(ii) The calculated value is higher than the actual value. [1]
Since energy is lost to the surroundings. **OR** Some energy is absorbed by the heater and the thermometer. [1]
OR
Not all the energy supplied by the heater goes to the metal. [1]

(d) Glass is not a good conductor of heat. **OR** The heat conductivity of glass is poor. [1]

11. (a) (i) $\dfrac{R - R_0}{R_{100} - R_0} = \dfrac{\theta - 0}{100 - 0}$ [1]

$\therefore\ \dfrac{R - 102.00}{140.51 - 102.00} = \dfrac{60}{100}$

$\therefore\ R = 125.106\ \Omega$ <accepted 125.11 Ω **OR** 125 Ω> [1]

(ii) Actual temperature is lower than 60°C. [1]

(b) Since the actual temperature is lower than 60°C when heating stops, [1]
OR
The energy supplied is actually lower than it should be, [1]
thus, the experimental value of c_w is lower than the actual value. ($c_w = \dfrac{E}{m \cdot \Delta T}$) [1]