The following list of formulae may be found useful :

Equation of state for an ideal gas $pV = nRT$

Use the following data wherever necessary :

Molar gas constant $R = 8.31 \text{ J K}^{-1} \text{ mol}^{-1}$

Avogadro constant $N_A = 6.02 \times 10^{23} \text{ mol}^{-1}$

Part A : HKCE examination questions

1. **< HKCE 1980 Paper II - 13 >**

6×10^{-3} m^3 of a gas is contained in a vessel at 91°C and a pressure of 4×10^5 Pa. If the density of the gas at s.t.p. (0°C and 10^5 Pa) is 1.2 kg m^{-3}, what is the mass of the gas ?

A. 7.2 g
B. 14.4 g
C. 21.6 g
D. 28.8 g

2. **< HKCE 1981 Paper II - 14 >**

An inexpansible vessel contains 1.2 kg of a gas at 300 K. What is the mass of gas expelled from the vessel if it is heated from 300 K to 400 K under constant pressure ?

A. 0.9 kg
B. 0.75 kg
C. 0.6 kg
D. 0.3 kg

3. **< HKCE 1983 Paper II - 12 >**

A fixed mass of gas has its temperature changed from 127°C to 27°C at constant pressure. The ratio of the new volume to the old volume is

A. 27 : 127
B. 127 : 27
C. 3 : 4
D. 4 : 3

4. **< HKCE 1985 Paper II - 12 >**

The initial pressure of a fixed mass of gas at 25°C is 2×10^5 Pa. What would its pressure be if the gas were reduced to half of its original volume and its temperature were increased to 95°C ?

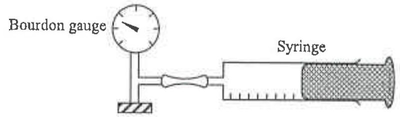
A. 1.23×10^5 Pa
B. 3.24×10^5 Pa
C. 4.94×10^5 Pa
D. 15.2×10^5 Pa

5. **< HKCE 1986 Paper II - 22 >**

If the pressure of a fixed mass of gas of initial volume V is doubled and its absolute temperature halved, its volume becomes

A. $\frac{1}{4}V$
B. $\frac{1}{2}V$
C. $2V$
D. $4V$

6. **< HKCE 1986 Paper II - 17 >**

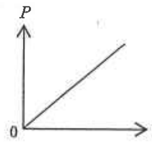


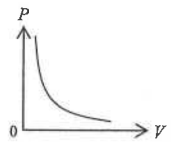
In the experiment shown in the diagram, volume of the air inside the syringe is 25 ml when the pressure is 1.0×10^5 N m^{-2}. What is the volume of the air when the pressure is 0.5×10^5 N m^{-2} ? (Assume that mass of the air in the syringe is constant.)

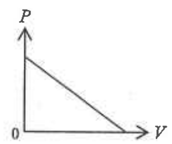
A. 30 ml
B. 50 ml
C. 70 ml
D. 100 ml

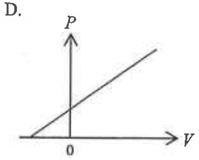
7. **< HKCE 1986 Paper II - 20 >**

Which of the following graphs correctly shows the relation between the pressure (P) and the volume (V) of a fixed mass of gas under constant temperature ?

A.


B.


C.


D.


8. **< HKCE 1989 Paper II - 22 >**

A cylinder contains a gas at a pressure of 10^5 Pa and a temperature of 20°C. It is compressed to half of its original volume and the temperature increases to 55°C. What is the final pressure of the gas ?

A. 0.56×10^5 Pa
B. 0.73×10^5 Pa
C. 1.79×10^5 Pa
D. 2.24×10^5 Pa

9. **< HKCE 1990 Paper II - 19 >**

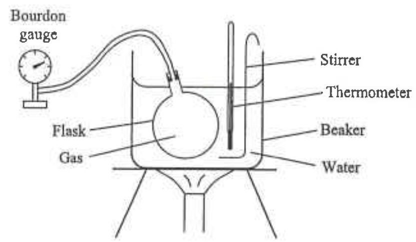
The pressure of a fixed mass of gas at 25°C is 2×10^5 Pa. How would its pressure be if the gas were reduced to half its volume and its temperature were increased to 95°C ?

A. 1.23×10^5 Pa
B. 2.47×10^5 Pa
C. 4.94×10^5 Pa
D. 15.2×10^5 Pa

10. **< HKCE 1991 Paper II - 20 >**

The apparatus shown is used to study the relation between the temperature and the pressure of a fixed mass of gas at constant volume. Which of the following is NOT correct ?

A. Stir the water before taking a reading.
B. Immerse the whole flask in water.
C. Prevent the thermometer from touching the bottom of the beaker.
D. Connect the Bourdon gauge to the flask with a long tube.



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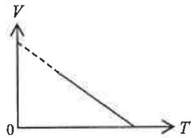
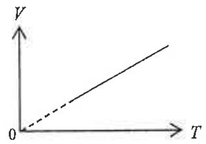
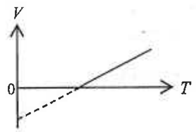
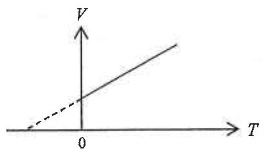
11. **< HKCE 1991 Paper II - 17 >**

Which of the following graphs correctly shows the variation of volume V with absolute temperature T of a fixed mass of gas at constant pressure ?

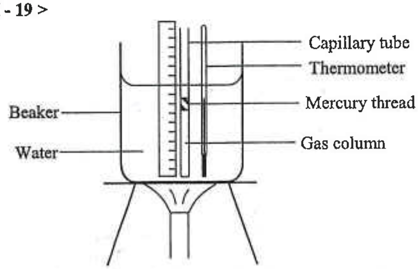
A.


B.


C.


D.


12. **< HKCE 1992 Paper II - 19 >**

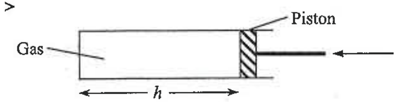


The apparatus shown in the figure is used to study the relation between the volume and temperature of a fixed mass of gas at constant pressure. Which of the following statements is/are correct ?

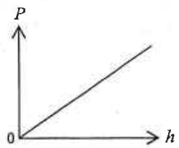
(1) Immersing the whole gas column in water.
(2) Sealing the capillary tube at both ends.
(3) Preventing the thermometer from touching the bottom of the beaker.

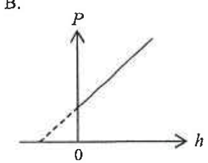
A. (1) only
B. (2) only
C. (1) & (3) only
D. (2) & (3) only

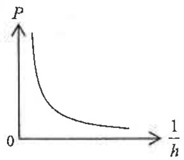
13. **< HKCE 1992 Paper II - 21 >**

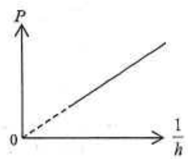


A column of gas is compressed slowly as shown in the figure above. Which of the following graphs correctly shows the relation between the gas pressure P and the length of the gas column h ?

A.


B.


C.


D.


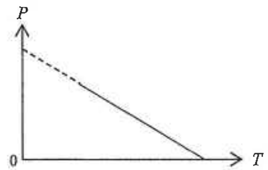
14. **< HKCE 1993 Paper II - 21 >**

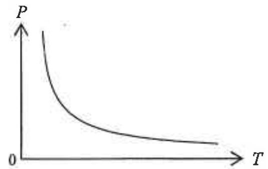
The absolute temperature of a fixed mass of gas is T. If the pressure and volume of the gas are both doubled, its absolute temperature becomes

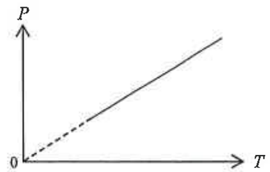
A. $\frac{1}{4}T$
B. $\frac{1}{2}T$
C. $2T$
D. $4T$

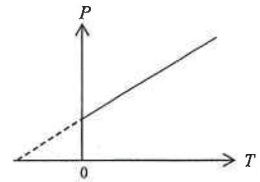
15. **< HKCE 1994 Paper II - 18 >**

Which of the following graphs correctly shows the relation between the pressure P and the absolute temperature T of a fixed mass of gas at constant volume ?

A.


B.


C.


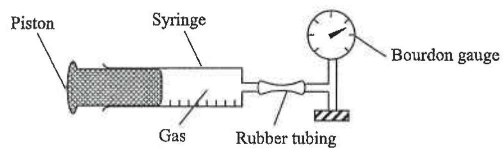
D.


16. **< HKCE 1994 Paper II - 19 >**

The pressure of a fixed mass of gas at 30°C is 3×10^5 Pa. What would be its pressure if the volume of the gas is doubled and its temperature is increased to 60°C ?

A. 1.65×10^5 Pa
B. 3.00×10^5 Pa
C. 5.46×10^5 Pa
D. 6.59×10^5 Pa

17. **< HKCE 1995 Paper II - 20 >**



The above apparatus is used to study the relationship between the pressure and volume of a fixed mass of gas at constant temperature. Which of the following can improve the accuracy of the experiment ?

(1) Pressing the piston quickly.
(2) Using a large syringe.
(3) Using a short length of rubber tubing.

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

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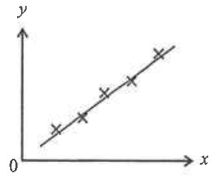
18. **< HKCE 1995 Paper II - 21 >**

The graph shows the result obtained when an experiment is performed to study Boyle's Law. What do the axes of the graph represent ?



	y axis	*x* axis
A.	Volume	Temperature
B.	Volume	1 / Temperature
C.	Pressure	Volume
D.	Pressure	1 / Volume

19. **< HKCE 1996 Paper II - 22 >**

The volume of a fixed mass of gas is V. If the pressure of the gas is doubled and its absolute temperature is reduced to half of the initial value, the volume of the gas becomes

A. $V/4$.
B. $V/2$.
C. $2V$.
D. $4V$.

20. **< HKCE 1996 Paper II - 16 >**

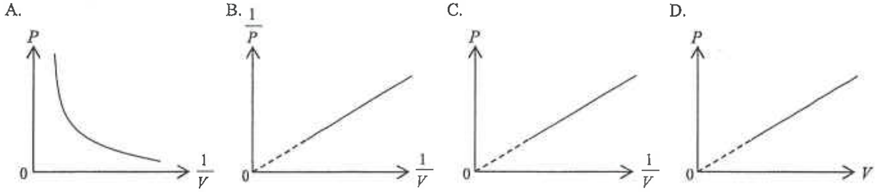
The temperature of two gases are 0°C and 100°C respectively. Express the temperature difference of the two gases in absolute temperature scale.

A. 0 K
B. 100 K
C. 273 K
D. 373 K

21. **< HKCE 1997 Paper II - 18 >**

Which of the following graphs correctly shows the relation between the pressure P and volume V of a fixed mass of gas at constant temperature ?

A. B. C. D.



22. **< HKCE 1997 Paper II - 17 >**

A fixed mass of gas at 120°C is heated at constant volume so that its pressure is tripled. Find the new temperature of the gas.

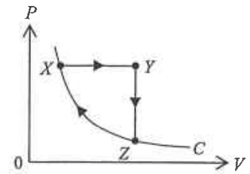
A. 40°C
B. 360°C
C. 906°C
D. 1179°C

23. **< HKCE 1999 Paper II - 18 >**

A cylinder contains a fixed mass of gas at a pressure of 10^5 N m^{-2} and a temperature of 27 °C. The cylinder is compressed to half of its original volume and the pressure increases to 3×10^5 N m^{-2}. Find the final temperature of the gas.

A. 40.5 °C
B. 177 °C
C. 313.5 °C
D. 450 °C

24. **< HKCE 2000 Paper II - 23 >**

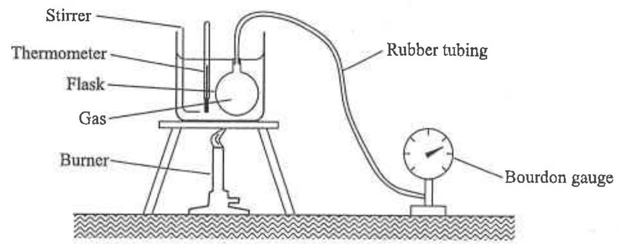


The curve C in the graph shows the P-V relation of a fixed mass of ideal gas at a certain temperature. Point X denotes the initial state of the gas. The state of the gas is now changed along the path shown from X to Y, then from Y to Z, and finally from Z back to X along the curve C. Which of the following statements is/are correct ?

(1) The temperature of the gas remains unchanged in the transition from X to Y.
(2) The temperature of the gas decreases in the transition from Y to Z.
(3) The temperature of the gas remains unchanged in the transition from Z to X.

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

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



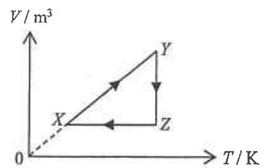
The above apparatus is used to study the relation between pressure and temperature of a fixed mass of gas at constant volume. Which of the following can improve the accuracy of the experiment ?

(1) using a larger flask
(2) using a shorter length of rubber tubing to connect the gauge and the flask
(3) setting up a control experiment with the burner removed

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

26. **< HKCE 2001 Paper II - 21 >**

The graph shows the V-T relation of a fixed mass of ideal gas. Point X denotes the initial state of the gas. The gas changes its state from X to Y, then from Y to Z and finally from Z back to X along the path shown. Which of the following statements about the pressure of the gas is/are correct ?



(1) The pressure remains unchanged in the transition from X to Y.
(2) The pressure increases in the transition from Y to Z.
(3) The pressure decreases in the transition from Z to X.

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

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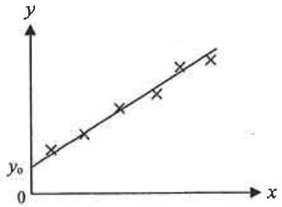
27. < HKCE 2002 Paper II - 22 >



The above graph shows the result obtained when an experiment is performed to study the relation between the pressure and temperature of a fixed mass of gas at constant volume. Which of the following statements is/are correct ?

(1) The y- and x-axes denote the pressure and temperature of the gas respectively.
(2) The slope of the graph denotes the volume of the gas.
(3) The intercept y_0 denotes the absolute zero temperature.

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

28. < HKCE 2003 Paper II - 20 >

The difference in absolute temperature of two bodies is 100 K. Express the temperature difference in degree Celsius.

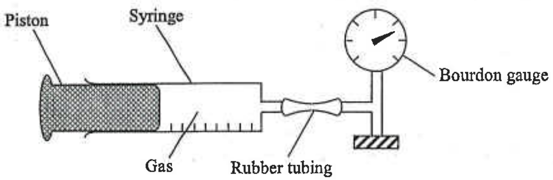
A. −173°C
B. 100°C
C. 273°C
D. 373°C

29. < HKCE 2003 Paper II - 23 >

A tyre of a car is filled with air at a temperature of 20°C and a pressure of 200 kPa. After driving for some time, the temperature of the air insider the tyre increases to 30°C and the capacity of the tyre increases by 1%. Find the pressure inside the tyre.

A. 188 kPa
B. 205 kPa
C. 273 kPa
D. 297 kPa

30. < HKCE 2003 Paper II - 24 >



The above apparatus is used to study the relation between the pressure and volume of a fixed mass of gas at constant temperature. Which of the following can improve the accuracy of the experiment ?

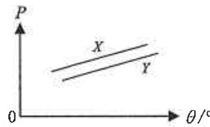
A. using a larger syringe
B. pushing the piston quickly
C. using a longer length of rubber tubing
D. setting a control experiment with the bourdon gauge removed

Part B : HKAL examination questions

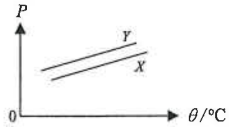
31. < HKAL 1987 Paper I - 14 >

Two vessels X and Y contain equal masses of an ideal gas. X has a greater volume than Y. When the temperature θ changes, which of the following represents the variation of the pressure P of the gas in each vessel with temperature θ ?

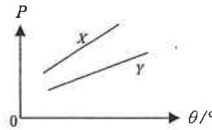
A.



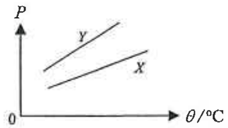
B.



C.



D.



32. < HKAL 1988 Paper I - 20 >

A metal vessel with a small opening contains 1.2 kg of gas at 300 K. Find the mass of gas expelled from the vessel if it is heated from 300 K to 400 K under constant pressure.

A. 0.25 kg
B. 0.30 kg
C. 0.60 kg
D. 0.75 kg

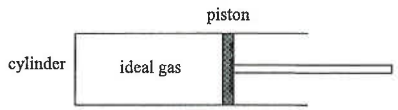
33. < HKAL 1993 Paper I - 17 >

An inexpansible vessel contains air at 50°C. What percentage of air remains in the vessel if it is heated to 150°C under constant pressure ?

A. 76%
B. 67%
C. 63%
D. 53%

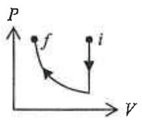
34. < HKAL 1993 Paper I - 16 >

A cylinder fitted with a smooth piston contains an ideal gas as shown below.

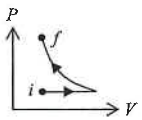


Firstly, the piston is held fixed and the gas is cooled. Secondly, the piston is pushed inwards slowly under constant temperature. If i is the initial state and f is the final state, which of the following graphs represents the variation of gas pressure P with gas volume V ?

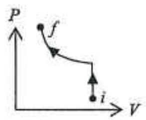
A.



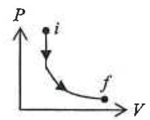
B.



C.



D.



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35. **< HKAL 1995 Paper IIA - 20 >**

The pressure of an ideal gas in a container is P_o. If the number of gas molecules is halved, the volume of the container is doubled and the temperature is kept constant, what would then be the pressure in the container ?

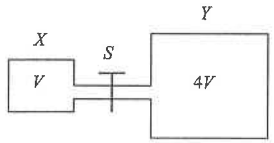
A. $\frac{1}{4}P_o$

B. $\frac{1}{2}P_o$

C. P_o

D. $2P_o$

36. **< HKAL 1999 Paper IIA - 37 >**



Two different containers X and Y of volume V and $4V$ respectively are connected by a narrow tube as shown. Initially the tap S is closed and an ideal gas is contained in X at a pressure of 400 kPa while container Y is evacuated. The tap S is then opened. Which of the following statements is correct when equilibrium is finally reached ?

A. The gas pressure in X is 100 kPa.

B. There are still gas molecules moving through the tap S.

C. The product of pressure and volume of the gas in X is equal to that in Y.

D. The density of gas molecules in X is greater than that in Y.

37. **< HKAL 2001 Paper IIA - 4 >**

Which of the following quantities is/are vector ?

(1) change of momentum

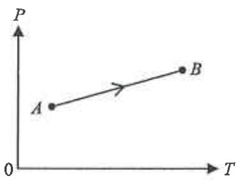
(2) work

(3) pressure

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

38. **< HKAL 2002 Paper IIA - 38 >**

The graph shows the relation between the pressure P and the absolute temperature T of a fixed mass of an ideal gas, which changes from state A to state B along the path AB. Which of the following statements s/are correct ?



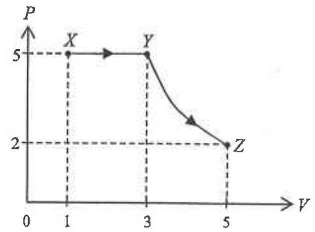
(1) The graph shows that P is directly proportional to T.

(2) All the points on line AB satisfy the relation $\frac{PV}{T}$ = constant.

(3) From state A to state B, the volume V of the gas increases.

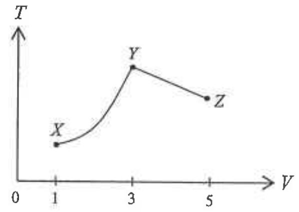
A. (1) only
B. (3) only
C. (1) & (2) only
D. (2) & (3) only

39. **< HKAL 2003 Paper IIA - 38 >**

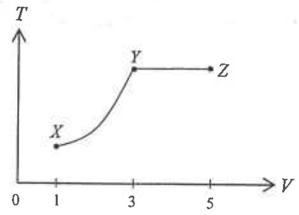


A fixed mass of an ideal gas changes from state X to state Y, then to state Z as shown in the pressure P against volume V graph. Which of the below graphs best shows how the variation of the absolute temperature T of the gas with its volume V ?

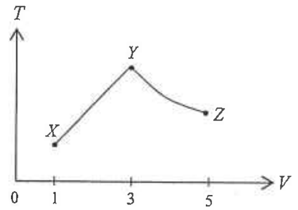
A.



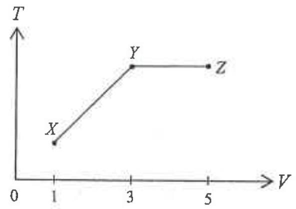
B.



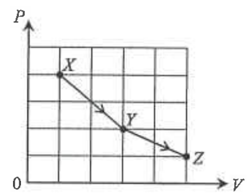
C.



D.



40. **< HKAL 2004 Paper IIA - 37 >**



An ideal gas undergoes a change from state X to state Y, then to state Z as shown in the pressure P against volume V graph. Which of the following descriptions about the temperature of the gas at X, Y and Z is correct ?

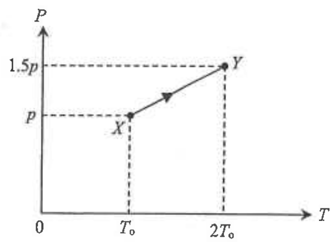
A. The temperature of the gas is lowest at X and highest at Y.

B. The temperature of the gas is lowest at X and highest at Z.

C. The temperature of the gas is lowest at Y and highest at X.

D. The gas has the same temperature at X, Y and Z.

41. **< HKAL 2005 Paper IIA - 21 >**



A gas in a vessel of fixed volume leaks gradually. The gas changes from state X of pressure p and absolute temperature T_o to state Y of pressure $1.5p$ and absolute temperature $2T_o$ as shown in the pressure P against absolute temperature T graph. What percentage of the original mass of the gas leaks out from the vessel in this process ?

A. 10%

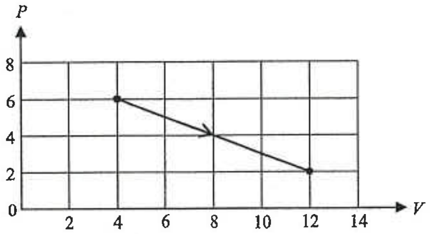
B. 20%

C. 25%

D. 50%

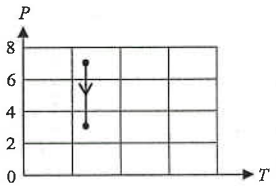
Provided by dse.life

42. **< HKAL 2009 Paper IIA - 35 >**

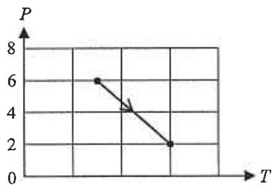


The pressure P of a fixed mass of ideal gas varies with its volume V as shown in the above figure. Which of the following graph best shows the corresponding pressure-temperature ($P - T$) relationship ?

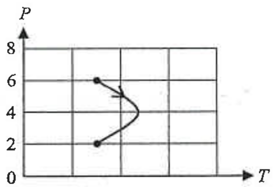
A.



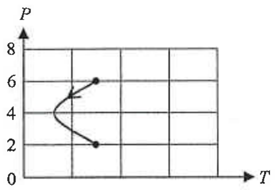
B.



C.



D.



43. **< HKAL 2012 Paper IIA - 28 >**

A closed container of volume 1 m^3 contains an ideal gas. The temperature of the gas is 25°C and the pressure of the gas is 1.01×10^5 Pa. Calculate the number of gas molecules in the container.

A. 2.46×10^{25}

B. 2.93×10^{25}

C. 2.46×10^{26}

D. 2.93×10^{26}

44. **< HKAL 2013 Paper IIA - 35 >**

A vessel contains an ideal gas at the temperature of 25°C and a pressure of 1.10×10^{-7} Pa. Estimate the number of gas molecules per unit volume in the vessel.

A. 2.67×10^{13}

B. 2.92×10^{13}

C. 3.19×10^{14}

D. 3.49×10^{14}

Part C : Supplemental exercise

45. A car tyre has a constant volume of 0.025 m^3. It contains 1.2 mol of air at a pressure of 280 kPa. An air pump delivers 8×10^{-3} mol of air into the tyre on each stroke of the pump. Calculate the minimum number of complete strokes of the pump so as to increase the air pressure in the tyre to 320 kPa. Assume the temperatures of air in the tyre and the pump are the same.

A. 20

B. 21

C. 22

D. 23

46. A car tyre has a constant volume of 12500 cm^3. The pressure of the air in the tyre is 275 kPa at a temperature of 30°C. Assume air is an ideal gas, what is the amount of air in the tyre ?

A. 1.2 mol

B. 1.4 mol

C. 1.6 mol

D. 1.8 mol

47. For air at room temperature of 25°C and atmospheric pressure of 10^5 Pa, calculate the order of magnitude of the number of molecules in 1 cm^3 of air.

A. 10^{25}

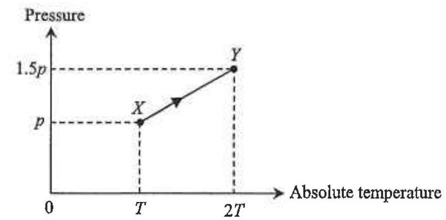
B. 10^{19}

C. 10^{16}

D. 10^{13}

Part D : HKDSE examination questions

48. **< HKDSE Sample Paper IA - 3 >**



As the gas in a vessel of fixed volume is heated, it gradually leaks out. The gas in the vessel changes from state X to state Y along the path XY shown in the plot of pressure against absolute temperature. What percentage of the original mass of the gas leaks out from the vessel in this process ?

A. 10%

B. 20%

C. 25%

D. 50%

Provided by dse.life

Part C : Supplemental exercise

45. A car tyre has a constant volume of 0.025 m^3. It contains 1.2 mol of air at a pressure of 280 kPa. An air pump delivers 8×10^{-3} mol of air into the tyre on each stroke of the pump. Calculate the minimum number of complete strokes of the pump so as to increase the air pressure in the tyre to 320 kPa. Assume the temperatures of air in the tyre and the pump are the same.

A. 20
B. 21
C. 22
D. 23

46. A car tyre has a constant volume of 12500 cm^3. The pressure of the air in the tyre is 275 kPa at a temperature of 30°C. Assume air is an ideal gas, what is the amount of air in the tyre ?

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B. 1.4 mol
C. 1.6 mol
D. 1.8 mol

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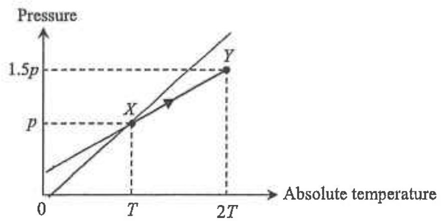
A. 10^{25}
B. 10^{19}
C. 10^{16}
D. 10^{13}

Part D : HKDSE examination questions

48. **< HKDSE Sample Paper IA - 3 >**

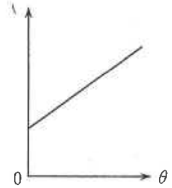


As the gas in a vessel of fixed volume is heated, it gradually leaks out. The gas in the vessel changes from state X to state Y along the path XY shown in the plot of pressure against absolute temperature. What percentage of the original mass of the gas leaks out from the vessel in this process ?

A. 10%
B. 20%
C. 25%
D. 50%

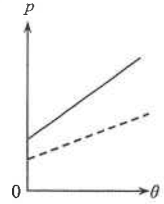
49. **< HKDSE 2012 Paper IA - 3 >**

An ideal gas is contained in a closed vessel of fixed volume. The graph below shows the variation of pressure p of the gas against its Celsius temperature θ.

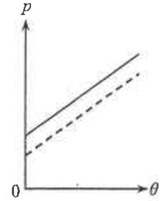


If the number of gas molecules in the vessel is halved, which graph of the dotted line best shows the relationship between p and θ ?

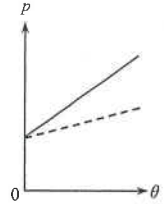
A.



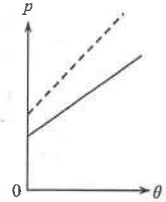
B.



C.



D.



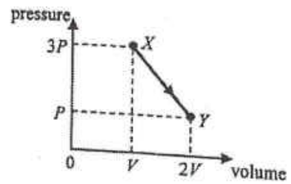
50. **< HKDSE 2017 Paper IA - 4 >**

The pressure of a fixed mass of an ideal gas at 10°C is 2×10^5 N m^{-2}. If the volume of the gas is reduced to half of its original volume and its temperature is increased to 100°C, what would the pressure be ?

A. 1.00×10^5 N m^{-2}
B. 1.32×10^5 N m^{-2}
C. 4.00×10^5 N m^{-2}
D. 5.27×10^5 N m^{-2}

51. <HKDSE 2020 Paper IA-3>

A fixed mass of an ideal gas expands from state X to state Y through a process as represented in the pressure-volume graph below.



If the temperature of the gas at state Y is 25 °C, what is its temperature at state X ?

A. −74.3 °C
B. 16.7 °C
C. 37.5 °C
D. 174 °C

Provided by dse.life

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. C	11. B	21. C	31. D	41. C	51. D
2. D	12. C	22. C	32. B	42. C	
3. C	13. D	23. B	33. A	43. A	
4. C	14. D	24. D	34. A	44. A	
5. A	15. C	25. C	35. A	45. C	
6. B	16. A	26. D	36. B	46. B	
7. B	17. D	27. A	37. A	47. B	
8. D	18. D	28. B	38. D	48. C	
9. C	19. A	29. B	39. C	49. A	
10. D	20. B	30. A	40. A	50. D	

M.C. Solution

1. C

By $\frac{P_1 V_1}{T_1} = \frac{P_2 V_2}{T_2}$

$\therefore \frac{(4\times10^5)(6\times10^{-3})}{(91+273)} = \frac{(10^5)\cdot V_2}{(273)}$ $\quad \therefore V_2 = 0.018 \text{ m}^3$

mass = density × volume = 1.2 × 0.018 = 0.0216 kg = 21.6 g

2. D

$\frac{V_1}{300} = \frac{V_2}{400}$

$\therefore \frac{V_1}{V_2} = \frac{3}{4}$

$\therefore \frac{1}{4}$ volume of gas inside the vessel is expelled.

$\therefore$ mass expelled $= 1.2\times\frac{1}{4} = 0.3$ kg

3. C

By $\frac{V_1}{T_1} = \frac{V_2}{T_2}$

$\therefore \frac{V_1}{(127+273)} = \frac{V_2}{(27+273)}$ $\quad \therefore \frac{V_2}{V_1} = \frac{3}{4}$

4. C

By $\frac{P_1 V_1}{T_1} = \frac{P_2 V_2}{T_2}$

$\therefore \frac{(2\times10^5)V}{25+273} = \frac{P_2\cdot(\frac{1}{2}V)}{95+273}$

$\therefore P_2 = 4.94 \times 10^5$ Pa

5. A

By $\frac{P_1 V_1}{T_1} = \frac{P_2 V_2}{T_2}$

$\therefore \frac{P\cdot V}{T} = \frac{(2P)\cdot V_2}{\frac{1}{2}T}$

$\therefore V_2 = \frac{V}{4}$

6. B

By $P_1 V_1 = P_2 V_2$

$\therefore (1.0 \times 10^5)(25) = (0.5 \times 10^5)\, V_2$

$\therefore V_2 = 50$ ml

7. B

$P\,V$ = constant

$\therefore P \propto \frac{1}{V}$

$\therefore P \sim V$ graph is a curve.

8. D

By $\frac{P_1 V_1}{T_1} = \frac{P_2 V_2}{T_2}$

$\therefore \frac{(10^5)\cdot V}{(20+273)} = \frac{P_2\cdot(\frac{1}{2}V)}{(55+273)}$

$\therefore P_2 = 2.24 \times 10^5$ Pa

9. C

By $\frac{P_1 V_1}{T_1} = \frac{P_2 V_2}{T_2}$

$\therefore \frac{(2\times10^5)V}{25+273} = \frac{P_2\cdot(\frac{1}{2}V)}{95+273}$

$\therefore P_2 = 4.94 \times 10^5$ Pa

Provided by dse.life

10. D

✓ A. Stir the water ⇒ to ensure uniform temperature of water

✓ B. Immerse the whole flask ⇒ to ensure that all the gas inside the flask is heated by the water bath

✓ C. Since the bottom of beaker is hotter than the water in beaker

× D. Long tube ⇒ volume of air in the tube is not negligible but the air cannot be heated by the water

11. B

By Volume-Temperature relation : $\frac{V}{T}$ = constant

$\therefore\ V \propto T$

as T is the absolute temperature in Kelvin scale

12. C

✓ (1) Immerse the whole column in water ⇒ all the gas can be heated by the water

× (2) Seal the tube ⇒ pressure of the trapped gas cannot be kept constant

✓ (3) Bottom of beaker is hotter than the water in beaker

13. D

Boyle's Law : PV = constant and $V \propto h$,

$\therefore\ P \propto \frac{1}{V} \propto \frac{1}{h}$

$\therefore\ P \sim 1/h$ is a straight line passing through the origin

14. D

By $\frac{P_1 V_1}{T_1} = \frac{P_2 V_2}{T_2}$

$\therefore\ \frac{(P)\cdot(V)}{(T)} = \frac{(2P)\cdot(2V)}{T_2}$ $\qquad \therefore\ T_2 = 4\,T$

15. C

By Pressure-Temperature relation : $\frac{P}{T}$ = constant

$\therefore\ P \propto T$ as T is the absolute temperature in Kelvin scale

$\therefore$ The graph is a straight line passing through the origin of 0 K.

16. A

By $\frac{P_1 V_1}{T_1} = \frac{P_2 V_2}{T_2}$

$\therefore\ \frac{(3\times10^5)\cdot(V)}{(30+273)} = \frac{P_2\cdot(2V)}{(60+273)}$ $\qquad \therefore\ P_2 = 1.65 \times 10^5$ Pa

17. D

× (1) Press the piston quickly ⇒ Temperature of the gas rises
$\therefore$ Boyle's Law cannot be held

✓ (2) Use larger syringe ⇒ volume of gas in rubber tubing becomes negligible and can be neglected

✓ (3) Shorter rubber tubing ⇒ volume of gas in rubber tubing becomes negligible

18. D

Boyle's Law :

PV = constant

OR

$P \propto \frac{1}{V}$.

$\therefore$ The graph of P against $\frac{1}{V}$ gives a straight line passing through the origin.

19. A

By $\frac{P_1 V_1}{T_1} = \frac{P_2 V_2}{T_2}$

$\therefore\ \frac{(P)\cdot(V)}{(T)} = \frac{(2P)\cdot V_2}{\frac{1}{2}T}$

$\therefore\ V_2 = \frac{V}{4}$

20. B

$\Delta T = (100+273) - (0+273) = 100$ K

21. C

Boyle's Law :

PV = constant

$\therefore\ P \propto \frac{1}{V}$.

$\therefore$ The graph of P against $\frac{1}{V}$ gives a straight line passing through the origin.

22. C

By $\frac{P_1}{T_1} = \frac{P_2}{T_2}$

$\therefore\ \frac{(P)}{(120+273)} = \frac{(3P)}{(\theta_2+273)}$

$\therefore\ \theta_2 = 906$°C

Provided by dse.life

23. B

By $\frac{P_1 V_1}{T_1} = \frac{P_2 V_2}{T_2}$

$\therefore \frac{(10^5)(V)}{(27+273)} = \frac{(3\times10^5)(\frac{V}{2})}{T_2}$ $\therefore T_2 = 450\text{ K} = 177°\text{C}$

24. D

× (1) From X to Y, P is constant $\therefore V\uparrow \Rightarrow T\uparrow$

✓ (2) From Y to Z, V is constant $\therefore P\downarrow \Rightarrow T\downarrow$

✓ (3) From Z to X, T is constant as C is the curve represents the P-V relation at a certain temperature

25. C

✓ (1) By using a large flask, the volume of the gas inside the tubing would become negligible

✓ (2) Shorter length of tubing enables the volume of gas inside the tubing to be negligible

× (3) No control apparatus is needed ; if the burner is removed, the experiment does not work

26. D

✓ (1) From X to Y, it is part of the straight line passing through origin which indicates $V \propto T$
since $V \propto T$ can only be held under constant pressure $\therefore$ pressure remains unchanged

✓ (2) From Y to Z, the temperature T remains unchanged, thus $P \propto 1/V$
as volume is decreased from Y to Z, the pressure must increase

✓ (3) From Z to X, the volume V remains unchanged, thus $P \propto T$
as temperature T is decreased from Z to X, the pressure must decrease

27. A

✓ (1) $P \propto T$ (in K), the graph shows the relationship between pressure but the temperature is in °C.

× (2) By $PV = nRT$ and $T = \theta + 273$

$\therefore P = \frac{nR}{V}(\theta + 273)$ $\therefore$ slope $= \frac{nR}{V}$

The slope is related to the volume but does not represent the volume of the gas.

× (3) The absolute zero temperature should be at −273°C.

28. B

Temperature difference ΔT : 1 K = 1°C

$\therefore \Delta T = 100\text{ K} = 100°\text{C}$

29. B

By $\frac{P_1 V_1}{T_1} = \frac{P_2 V_2}{T_2}$

$\therefore \frac{(200)(V)}{(20+273)} = \frac{P_2(1.01V)}{(30+273)}$ $\therefore P_2 = 205\text{ kPa}$

30. A

✓ A. By using a larger syringe, the volume of air inside the rubber tubing becomes negligible.

× B. Pushing the piston quickly would make the temperature increase.

× C. By using a longer length of tubing, the volume of air inside the tubing becomes significant,
but this volume is not counted in the experiment.

× D. In this experiment, no control is needed ; if the bourdon gauge is removed, pressure cannot be read.

31. D

By $PV = nRT$ $\therefore P = \frac{nR}{V}\cdot T$ $\therefore$ slope of the graph $= \frac{nR}{V}$

$\therefore$ X : greater volume $\Rightarrow$ smaller slope

Note that both lines when extrapolated should cut the T-axis at −273°C.

32. B

By $PV = nRT$

Let the pressure inside the vessel be P and the volume of the vessel be V.

At 300 K : $PV = n_1 R(300)$

At 400 K : $PV = n_2 R(400)$

$\therefore n_2 = \frac{3}{4} n_1$

Mass of gas remains in the vessel $= 1.2 \times \frac{3}{4} = 0.9$ kg

Mass of gas expelled from the vessel $= 1.2 - 0.9 = 0.3$ kg

33. A

By $PV = nRT$

Let the pressure inside the vessel be P and the volume of the vessel be V.

At 50°C : $PV = n_1 R(50+273)$

At 100°C : $PV = n_2 R(150+273)$

$n_2 = 0.76\, n_1$

Percentage of air remains in the vessel $= \frac{n_2}{n_1} = 0.76 \times 100\% \approx 76\%$

34. A

Fixed piston and cooled : no change in V $\therefore T\downarrow \Rightarrow P\downarrow$

Piston pushed inward slowly : no change in T $\therefore V\downarrow \Rightarrow P\uparrow$

35. A

Originally : $(P_o)V = nRT$

Finally : $P'(2V) = (\frac{1}{2}n)RT$

$\therefore P' = \frac{1}{4}P_o$

Provided by dse.life

36. B

× A. Since the temperature remains unchanged,

$P_X V_X + P_Y V_Y = P(V_X + V_Y)$

$\therefore\ (400)(V) + (0)(4V) = P(V + 4V) \quad \therefore\ P = 80 \text{ kPa}$

✓ B. At equilibrium, there are still gas molecules interflowing, although the net flow becomes zero.

× C. Finally, they have the same pressure. As their volume are not the same, PV cannot be the same.

× D. By $PV = nRT = \dfrac{M}{M_m} RT$, where M is the mass of the gas and M_m is the molar mass of the gas,

$\therefore\ P = \dfrac{M}{V} \times \dfrac{RT}{M_m}$

as both containers have same pressure P, same temperature T, and same molar mass M_m,

they have the same $\dfrac{M}{V}$, that is, the same density ρ, as $\rho = \dfrac{M}{V}$.

37. A

✓ (1) Change of momentum is a vector as momentum is a vector.

× (2) Work is a process to transfer energy, work does not have direction, it is a scalar.

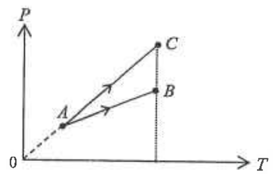
× (3) Pressure is a scalar, it exerts at every direction, thus it is not a vector.

38. D

× (1) Since the graph does not pass through the origin, P is not directly proportional to T.

✓ (2) Since the mass is fixed and it is an ideal gas, PV/T must be constant.

✓ (3) If the volume is constant,
then the line would pass through the origin
and changes from state A to state C as shown.
Compare with state C at the same temperature,
the pressure at B is smaller,
so its volume must be greater.



39. C

① From X to Y, pressure P is constant, thus V is proportional to the absolute temperature T.
The process represented in a T-V graph should be a straight line through origin.

② From Y to Z, since $P_Y V_Y \neq P_Z V_Z$, thus the temperature must not be constant.
The process represented in a T-V graph must not be a horizontal line.

40. A

By $PV = nRT \quad \therefore\ T \propto PV$

$\therefore\ T_X = 4k \quad T_Y = 6k \quad T_Z = 5k$

$\therefore$ The gas has highest temperature at Y and lowest temperature at X.

41. C

① $pV = n_1 R T_o$

② $(1.5p)V = n_2 R (2T_o)$

$\therefore\ \dfrac{n_2}{n_1} = \dfrac{3}{4}$

$\therefore$ Percentage of mass of gas leaks out $= 1 - \frac{3}{4} = 25\%$

42. C

When $P = 6$, $PV = (6) \times (4) = 24$

When $P = 4$, $PV = (4) \times (8) = 32$

When $P = 2$, $PV = (2) \times (12) = 24$

As $PV = nRT \quad \therefore\ PV \propto T$

$\therefore\ T$ (at $P = 6$) is equal to T (at $P = 2$)

but T (at $P = 4$) is greater than T (at $P = 6$).

43. A

By $PV = nRT$

$\therefore\ (1.01 \times 10^5)(1) = n(8.31)(25 + 273) \qquad \therefore\ n = 40.8 \text{ mol}$

Number of gas molecules $= 40.8 \times 6.02 \times 10^{23} = 2.46 \times 10^{25}$

44. A

$PV = nRT = \dfrac{N}{N_A} RT$

$\dfrac{N}{V} = \dfrac{PN_A}{RT} = \dfrac{(1.10 \times 10^{-7})(6.02 \times 10^{23})}{(8.31)(25 + 273)} = 2.67 \times 10^{13} \text{ m}^{-3}$

45. C

By $PV = nRT$

$\therefore\ P \propto n \qquad$ (V and T are constant)

$\therefore\ \dfrac{P_1}{P_2} = \dfrac{n_1}{n_2} \qquad \therefore\ \dfrac{(280)}{(320)} = \dfrac{(1.2)}{n_2} \qquad \therefore\ n_2 = 1.37 \text{ mol}$

Consider the amount of air before and after the pumping :

$\therefore\ 1.2 + n \times (8 \times 10^{-3}) = 1.37 \qquad \therefore\ n = 21.3$

$\therefore$ Minimum number of strokes $= 22$

46. B

By $PV = nRT$

$\therefore\ (275 \times 10^3) \times (12500 \times 10^{-6}) = n \times (8.31) \times (30 + 273)$

$\therefore\ n = 1.4 \text{ mol}$

Provided by dse.life

47. B

By $P V = n R T$

$\therefore$ $(10^5)(1 \times 10^{-6}) = n(8.31)(25 + 273)$ $\therefore$ $n = 4.0 \times 10^{-5}$

$\therefore$ $N = n \times N_A = 4.0 \times 10^{-5} \times 6.02 \times 10^{23} = 2.4 \times 10^{19}$

$\therefore$ order of magnitude of $N = 10^{19}$

48. C

① $(p) V = n_X R (T)$

② $(1.5p) V = n_Y R (2T)$

$\therefore$ $\dfrac{n_Y}{n_X} = \dfrac{3}{4}$

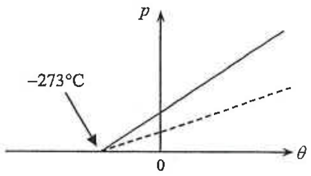
$\therefore$ Percentage of mass of gas leaks out $= 1 - \dfrac{3}{4} = 25\%$

49. A

By $p V = n R T = n R (\theta + 273)$ $\therefore$ $p = \dfrac{nR}{V}(\theta + 273)$

As compared with the slope-intercept form : $y = m x + c$

$\therefore$ slope $= \dfrac{n R}{V}$



If the number of gas molecules is halved,
the number of mole n is halved, the slope is halved.

Moreover, the x-intercept is the absolute zero (− 273°C) which should be unchanged.

50. D

By $\dfrac{P_1 V_1}{T_1} = \dfrac{P_2 V_2}{T_2}$

$\therefore$ $\dfrac{(2 \times 10^5)(V)}{(10 + 273)} = \dfrac{P_2 (V/2)}{(100 + 273)}$ $\therefore$ $P_2 = 5.27 \times 10^5 \text{ N m}^{-2}$

The following list of formulae may be found useful :

Equation of state for an ideal gas $p V = n R T$

Use the following data wherever necessary :

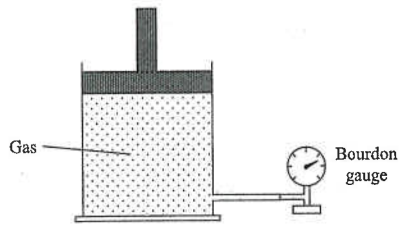
Molar gas constant $R = 8.31 \text{ J K}^{-1} \text{ mol}^{-1}$

Avogadro constant $N_A = 6.02 \times 10^{23} \text{ mol}^{-1}$

Part A : HKCE examination questions

1. **< HKCE 1981 Paper I - 4 >**

A gas is contained in a cylinder fitted with a piston as shown in the below figure. Its volume is given by the calibration on the cylinder as 0.0015 m^3. The pressure reading on the Bourdon gauge is $2.5 \times 10^5 \text{ N m}^{-2}$.



(a) If the volume of the gas is reduced to $\frac{1}{4}$ of its original value without altering its temperature, find the new pressure of the gas. (3 marks)

(b) If the temperature of the gas is raised from its initial value of 27°C to 327°C, but with the volume kept constant at 0.0015 m^3, find the new pressure of the gas. (3 marks)

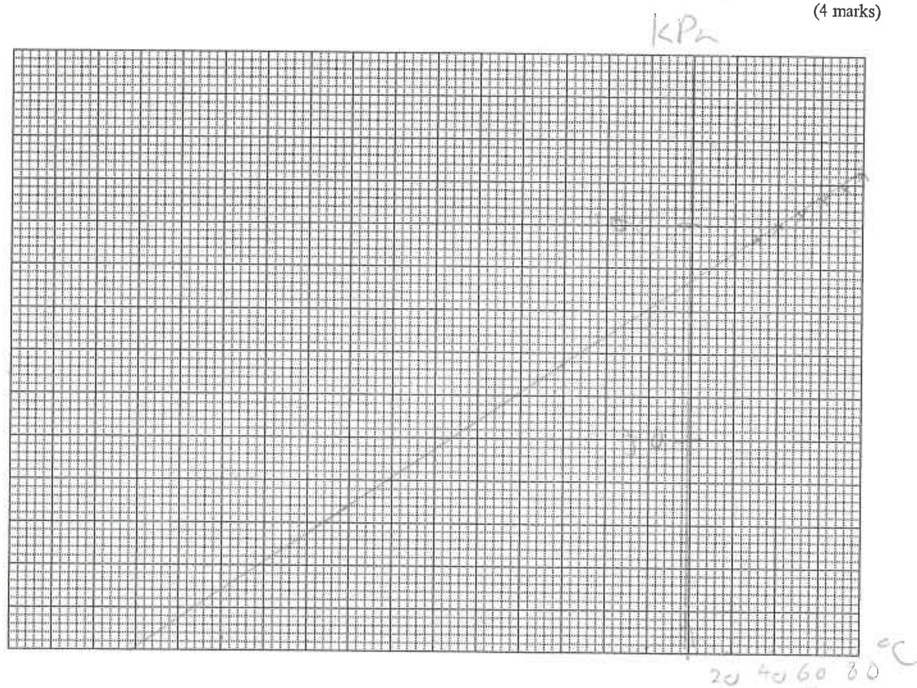
Provided by dse.life

2. **< HKCE 1983 Paper I - 4 >**

The table below shows the relationship of the pressure and temperature of a fixed mass of a gas :

Temperature / °C	30	40	50	60	70	80
Pressure / kPa	97	100	103	106	109	112

(a) Plot the pressure-temperature graph for temperatures ranging from −300°C to 100°C and pressures ranging from 0 kPa to 140 kPa. (You are recommended to use a scale of 1 cm to represent 20°C and 1 cm to represent 10 kPa). (4 marks)



(b) What is the intercept of your graph on the temperature axis ? (2 marks)

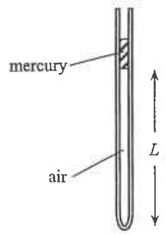
(c) If the Celsius temperature is converted to a temperature in a new scale by adding the absolute value of the intercept you obtained in (b), find the relation between the pressure and the new temperature from your graph. (2 marks)

(d) If the pressure of the gas in the experiment were increased to 150 kPa, what would be the temperature of the gas on the temperature scale you constructed in (c) ? (2 marks)

2. (e) Draw a diagram to show the experimental set-up you would use to obtain the above data. State TWO precautions that should be taken in this experiment. (5 marks)

Diagram

3. **< HKCE 1987 Paper I - 4 >**



In the above figure, a mercury thread is trapped in a uniform bored capillary tube which is used in an experiment to verify the volume-temperature relationship. The following data are recorded :

Temperature θ / °C	20	30	40	50	60	70	80
Length of air column L / mm	136	140	146	152	156	160	166

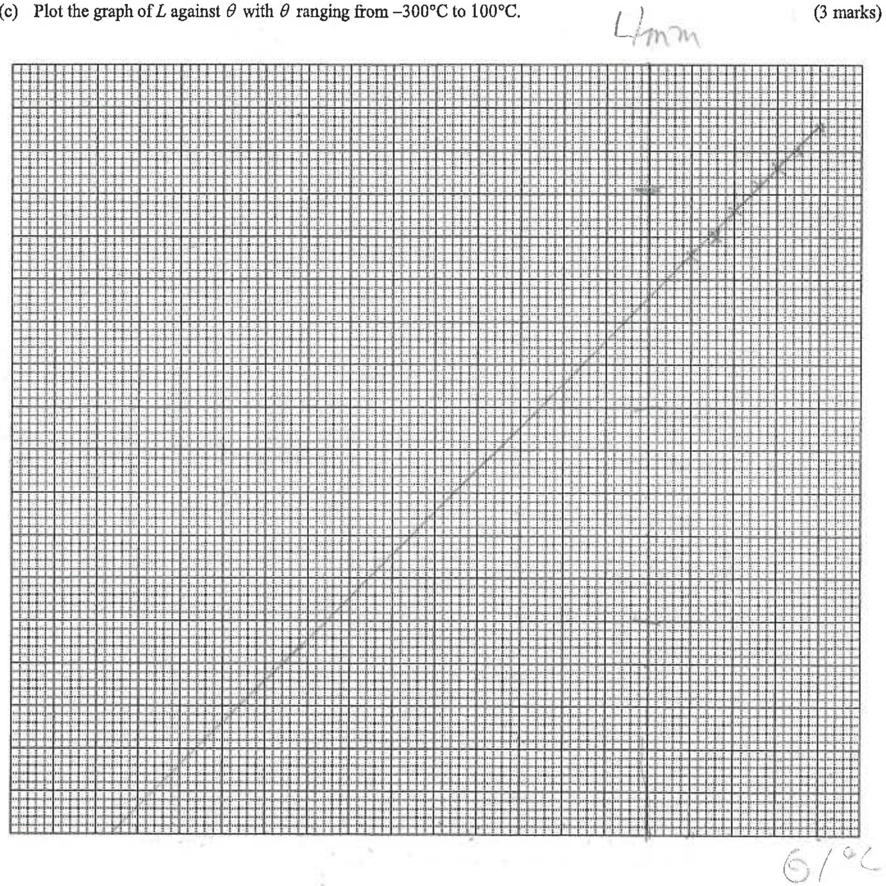
(a) Draw a diagram to show an experimental set-up and describe briefly the procedure in order to obtain the above data. (4 marks)

Diagram

(b) Name any TWO precautions in this experiment. (2 marks)

Provided by dse.life

3. (c) Plot the graph of L against θ with θ ranging from –300°C to 100°C. (3 marks)



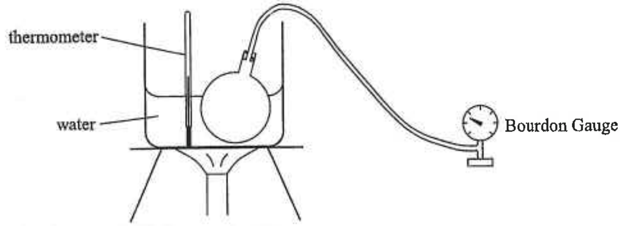
(d) What is the "absolute zero" as obtained from this experiment ? (2 marks)

(e) What is the relationship among L, θ and the "absolute zero" in (d) ? (2 marks)

(f) How does the pressure of the trapped air in the tube change with temperature ? (2 marks)

4. **< HKCE 1989 Paper I - 4 >**

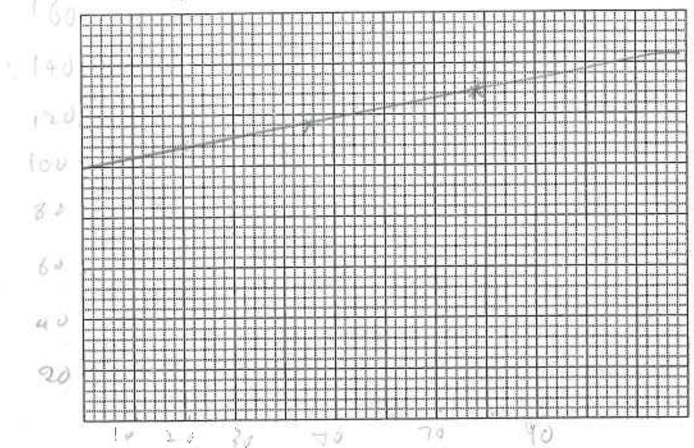
The below figure shows an experiment done by a student to find the variation of pressure of air inside a flask with temperature. The pressure P and the temperature θ are measured by Bourdon Gauge and a thermometer respectively.



(a) The following data are recorded in the experiment:

θ / °C	20	35	45	60	78	90	100
P / kN m^{-2}	107	112.5	116	121.5	128	132.5	136

Using a scale that 2 cm represents 10 kN m^{-2} and 1 cm represents 10°C, plot a graph of P against θ ranging from 0°C to 100°C. (5 marks)



(b) Find the equation relating the pressure and temperature from the graph in (a). (2 marks)

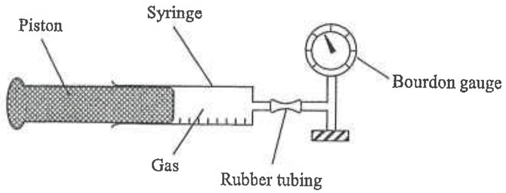
(c) The flask is then transferred into a trough of oil and the gauge reading is 118 kN m^{-2}. What is the temperature of the oil ? (2 marks)

(d) Give THREE suggestions to improve the experimental setup as shown in the figure. (3 marks)

Provided by dse.life

5. < HKCE 1994 Paper I - 4 >

A student uses the set-up shown in the below figure to study the relationship between the pressure and volume of a fixed mass of gas at constant temperature. The piston is pushed in or pulled out to vary the volume of gas and the corresponding pressure is measured by the Bourdon gauge.



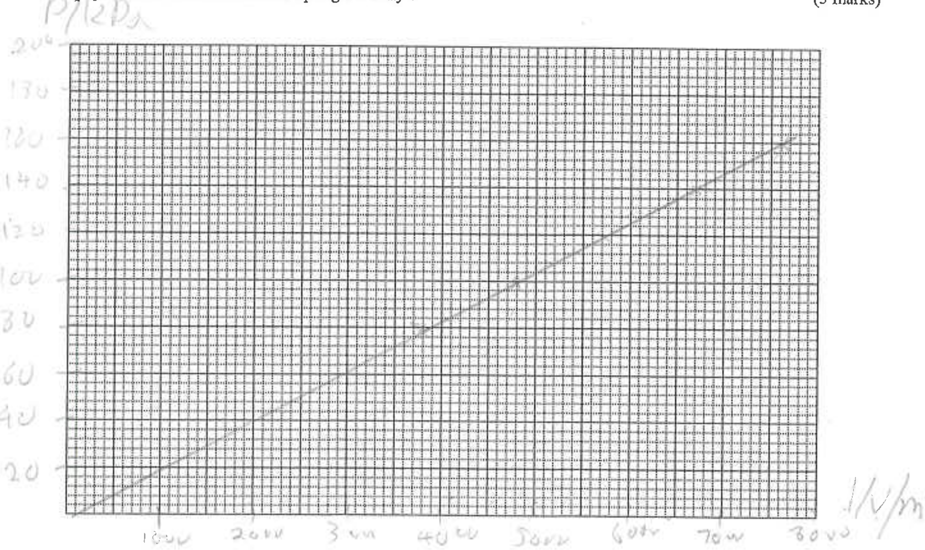
(a) Should the rubber tubing be long or short ? Explain briefly. State TWO other precautions that should be taken to improve the accuracy of the experiment. (4 marks)

(b) The following results are obtained in the experiment:

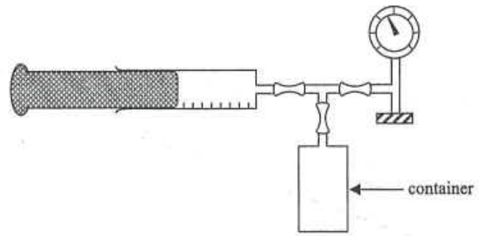
Pressure P / kPa	80	100	120	140	160
Volume V / m^3	2.60×10^{-4}	2.10×10^{-4}	1.75×10^{-4}	1.50×10^{-4}	1.31×10^{-4}
$1/V$ m^{-3}	3846	4762	5714	6667	7634

Plot P against $1/V$ on graph paper, with P ranging from 0 to 160 kPa and $1/V$ ranging 0 to 8000 m^{-3}.

What physical law is the student attempting to verify ? (5 marks)

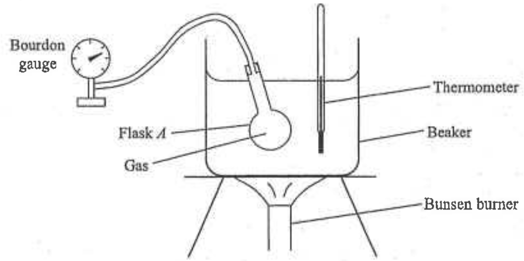


5. (c)



The student uses another set of apparatus as shown in the above figure to measure the volume of a container. Initially the readings of the syringe and the gauge are 1.8×10^{-4} m^3 and 100 kPa respectively. The piston is then completely pushed in and the reading of the gauge becomes 210 kPa. Assuming that temperature remains unchanged, calculate the volume of the container. (3 marks)

6. < HKCE 1999 Paper I - 9 >



David uses the set-up shown in the above figure to study the relationship between the pressure P and temperature θ of a fixed mass of gas inside a flask A. The following results are obtained :

Temperature θ / °C	20	36	50	64	80	98
Pressure P / kPa	102	109	111	115	124	129

(a) Using a scale of 1 cm to 10 kPa and 1 cm to 10°C, plot a graph of P against θ on graph paper, with P ranging from 0 to 140 kPa and θ ranging from 0 to 100°C. (4 marks)

< Graph on next page >

(b) From the graph in (a), David concludes that

The pressure (in kPa) of the gas is directly proportional to its temperature (in °C).

Comment on David's conclusion. (2 marks)

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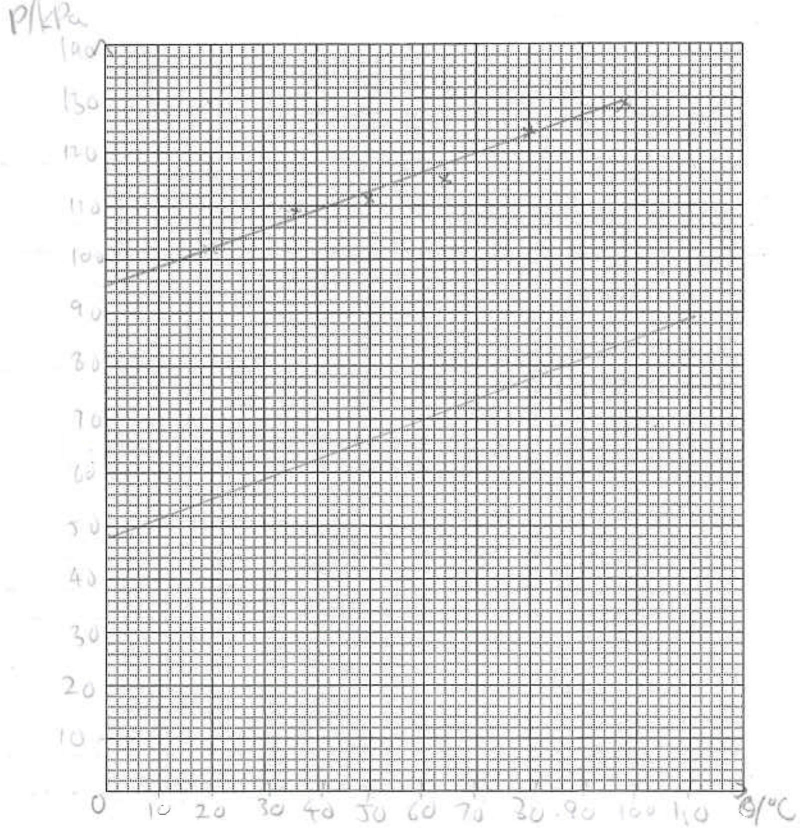
6.



(c) State **two** precautions that should be taken to improve the accuracy of the experiment. (2 marks)

(d) David uses a larger flask *B* to replace flask *A* and repeats the experiment. The volume of flask *B* is twice that of *A*. Assume that the masses of the gas in both flasks are the same.

(i) Estimate the gas pressure in flask *B* at 0°C. (2 marks)

(ii) On the graph in (a), draw the graph of *P* against θ you expect to obtain in this experiment. (1 mark)

7. **< HKCE 2001 Paper I - 2 >**

A metal can containing compressed gas at 200 kPa and 30°C is placed under direct sunlight for some time. If the temperature of the gas rises to 60°C, find the gas pressure inside the can. Assume that the volume of the can remains unchanged. (2 marks)

8. **< HKCE 2002 Paper I - 2 >**

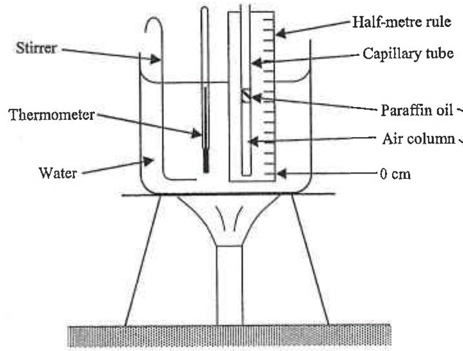


Figure 1

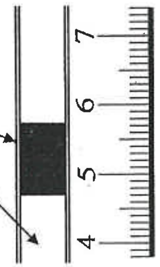


Figure 2

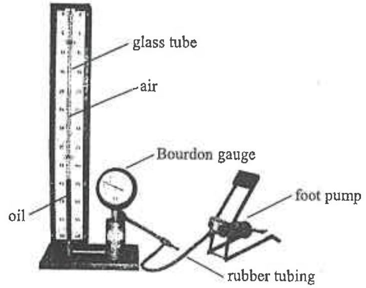
Figure 1 shows a set-up to study the relation between the volume and temperature of a column of air trapped in a uniform capillary tube by a drop of paraffin oil. Figure 2 shows the position of the paraffin oil when the temperature of the water is 25°C. A half-metre rule is used to measure the length of the air column in cm.

(a) Write down the length of the air column as shown in Figure 2. (1 mark)

(b) Estimate the length of the air column when the temperature of the water is increased to 80°C. State one assumption in your calculation. (3 marks)

Provided by dse.life

9. **< HKCE 2004 Paper I - 3 >**

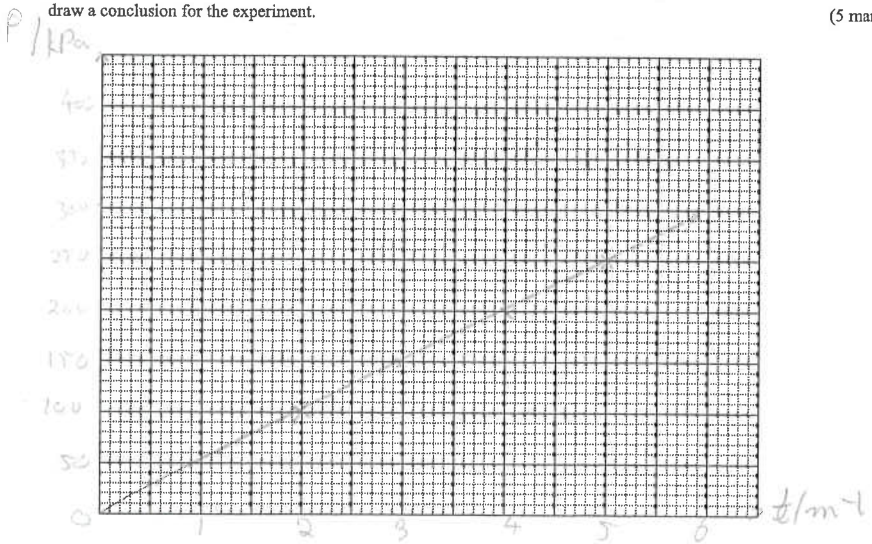


The Figure above shows a set-up used to study the relationship between the pressure and volume of a column of air trapped in a glass tube at constant temperature. The cross-section of the glass tube is uniform.

(a) The Table shows the results obtained.

Pressure P / kPa	100	150	200	250	300
Length of air column ℓ / m	0.49	0.34	0.25	0.20	0.17
$\frac{1}{\ell}$ / m^{-1}	2.04	2.94	4	5	5.87

Plot a graph of P against $\frac{1}{\ell}$ on graph paper, with P ranging from 0 to 400 kPa, and $\frac{1}{\ell}$ ranging from 0 to 6 m^{-1}. Hence draw a conclusion for the experiment. (5 marks)



(b) Suggest one precaution that should be taken to improve the accuracy of the experiment. (1 mark)

Part B : HKAL examination questions

10. **< HKAL 1986 Paper IIB - 2 >**

The density of a gas is equal to 1.43 kg m^{-3} at the standard temperature of 0°C and pressure of 1.01×10^5 Pa. What is the mass of 1 mole of the gas ? (2 marks)

11. **< HKAL 1990 Paper IIB - 8 >**

A cylinder fitted with a piston contains 0.2 mol of an ideal gas at a pressure of 10^5 Pa and a temperature of 301 K. The gas is

(1) first heated at constant pressure to 400 K, and then

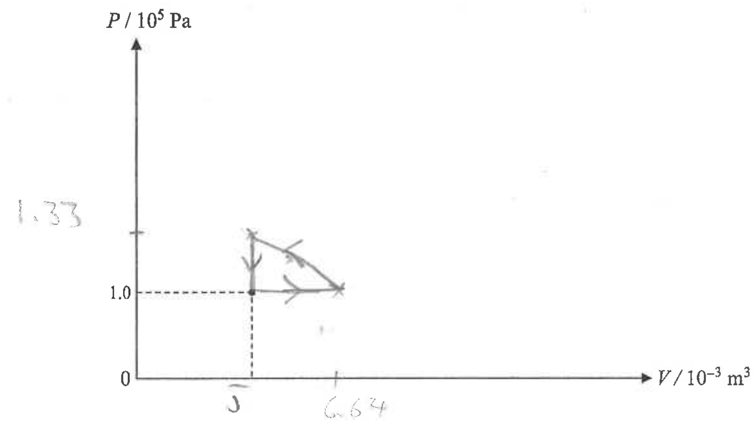
(2) compressed at the constant temperature of 400 K to its initial volume, and finally

(3) cooled at constant volume to its initial pressure of 10^5 Pa and temperature of 301 K.

(a) Find the initial volume V_1 of the gas and determine its volume V_2 after process (1) is completed. (2 marks)

(b) Find the final pressure after the compression process of (2) is completed. (2 marks)

(c) Hence sketch the above changes on a P - V diagram, inserting all the initial and final pressure and volume values for each of the processes (1), (2) and (3) (4 marks)



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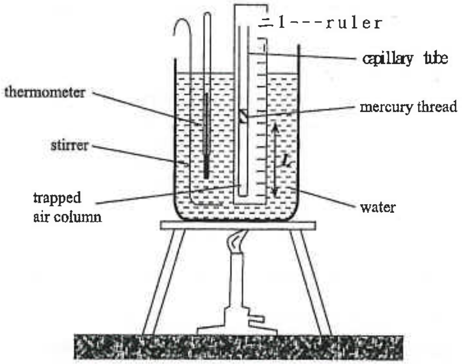
Part C : HKDSE examination questions

12. < HKDSE 2013 Paper 1B-2 >



The Figure above shows an air column trapped by a small mercury thread inside a uniform capillary tube. The set-up is heated by a water bath. The length of the air column L is measured at various temperature θ. Some of the results are tabulated below :

Temperature θ / °C	20					
Length of air column L / mm	64					

(a) Describe the procedure(s) to be done before taking a reading in order to ensure that the trapped air reaches the same temperature as the water. (2 marks)

(b) Assume that length L increases linearly with temperature θ throughout.

(i) Estimate the length of the air column when the temperature indicated by the thermometer is 65 °C. (2 marks)

(ii) Find the 'absolute zero' as obtained from this experiment. (2 marks)

13. < HKDSE 2015 Paper IB-2 >

The aqua-lung (a cylinder containing compressed air) for divers has a capacity of 1.0×10^4 cm^3. When the aqua-lung is filled, the air inside has a pressure of 210 atm (atmospheric pressure) at 24 °C. The air in the aqua-lung is allowed to expand through a pressure-reducing valve until its pressure equals that of the surrounding water before it is supplied to divers. Assume that the temperature of the air inside the aqua-lung is always equal to that of the surrounding water.

(a) A diver stays in water of temperature 24 °C and pressure 2.0 atm at a depth of 10 m. Find the total volume of air (in m^3) available for the diver from the aqua-lung at this water pressure. (2 marks)

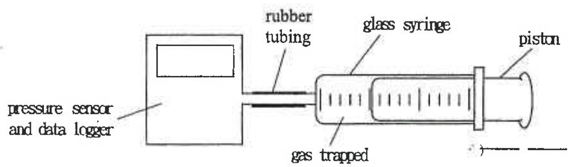
(b) The supply of air in (a) is sufficient for the diver to remain at such a depth for 1 hour.

(i) If the diver breathed in the same volume V_a (in cm^3) of air per minute, find V_a. (1 mark)

(ii) If the diver dives deeper where the water is of temperature 20 °C and pressure 4.5 atm, estimate how long (in minutes) the air in a fully-filled aqua-lung would last. Assume that the diver breathes in the same volume of air per minute as that found in (b) (i). (3 marks)

14. < HKDSE 2016 Paper IB-2 >

Figure (a)



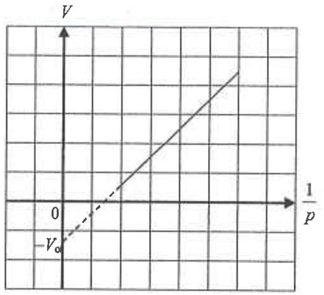
Judy uses the set-up shown in the Figure (a) to study the relationship between the pressure and volume of a fixed mass of gas at constant temperature. The volume V of the gas trapped is read directly from the syringe and the corresponding pressure p is measured by a data-logger via a pressure sensor.

(a) The initial volume and pressure of the gas are 6.0×10^{-5} m^3 and 1.0×10^5 Pa respectively at a room temperature of 25 °C. Estimate the number of gas molecules trapped in the syringe. (3 marks)

Provided by dse.life

14. (b) The piston is then pushed in or pulled out to vary V and p such that several pairs of readings are recorded. Figure (b) shows the graph of V against $\frac{1}{p}$ plotted.

Figure (b)



(i) State **ONE** experimental precaution for keeping the gas temperature constant. (1 mark)

(ii) The straight line graph does not pass through the origin but cuts the vertical axis at $-V_o$ instead. Suggest what V_o stands for. (1 mark)

(iii) If the experiment is repeated at a higher room temperature using this set-up with the same mass of the same gas, sketch the expected graph in Figure (b). (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) $P_1 V_1 = P_2 V_2$ [1]

$\therefore\ (2.5 \times 10^5) \times (0.0015) = P_2\,(0.0015 / 4)$ [1]

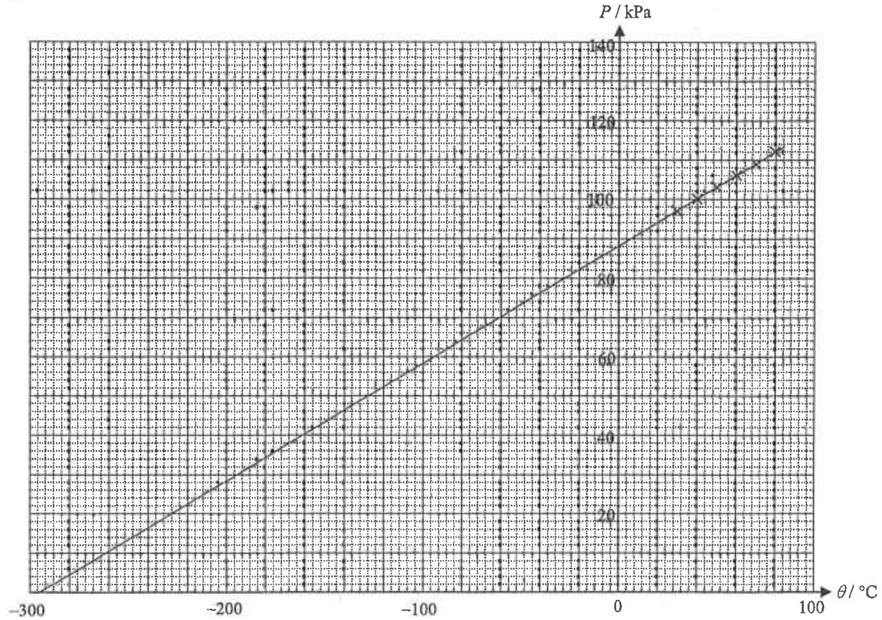
$\therefore\ P_2 = 10^6$ Pa [1]

(b) $\frac{P_1}{T_1} = \frac{P_2}{T_2}$ [1]

$\therefore\ \frac{(2.5 \times 10^5)}{(27 + 273)} = \frac{P_2}{(327 + 273)}$ [1]

$\therefore\ P_2 = 5 \times 10^5$ Pa [1]

2. (a)



< Two axes correctly labelled with proper units > [1]

< Scale correctly marked > [1]

< At least 4 points plotted correctly > [1]

< Best fitted straight line correctly drawn and extrapolated > [1]

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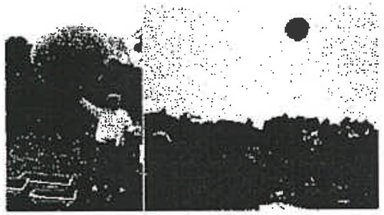
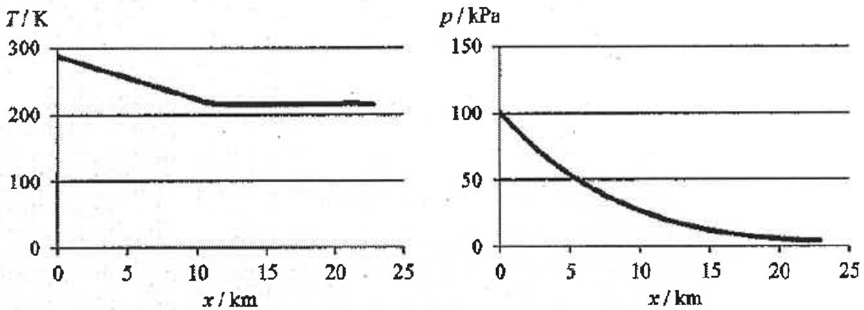
A weather balloon of volume 0.52 m^3 is filled with helium gas of temperature 15 °C and pressure 100 kPa at ground level.



(a) Find the amount of helium gas (in mol) in the balloon. (2 marks)

(b) The following graphs show the variation of air temperature T and atmospheric pressure p with height x above ground level.



The weather balloon is released and rises to the upper atmosphere. Assume that the temperature and pressure of the helium gas in the balloon are the same as those of the air outside at any height x.

(i) A student believes that as the air temperature decreases in the first 10 km, the volume of the balloon decreases. Referring to the graphs above, explain qualitatively why this belief is not correct. (2 marks)

(ii) In fact the weather balloon keeps on expanding when it rises. The air temperature becomes steady at 216 K from a height of 12 km onwards. When the balloon rises further beyond 12 km and its volume reaches 8 m^3,

(1) estimate the gas pressure in the balloon; (2 marks)

(2) hence find the corresponding height reached by the balloon. The variation of atmospheric pressure p with height x (in km) is given by

$$p = p_0 e^{-kx},$$

where p_0 is the atmospheric pressure at ground level and $k = 0.138\ \text{km}^{-1}$. (2 marks)

Provided by dse.life

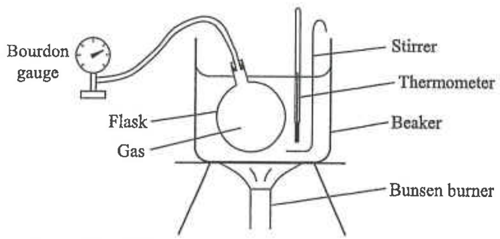
2. (b) intercept = – 295 °C < accept – 285°C to –305°C > [2]

(c) $\dfrac{P}{T}$ = constant where $T = \theta + 295$ **OR** $\dfrac{P}{\theta + 295}$ = constant [2]

(d) $\dfrac{(88)}{(0+295)} = \dfrac{(150)}{T}$ [1]

$\therefore$ T = 503 < accept 497 to 509 > [1]

(e)



< flask in water > [1]

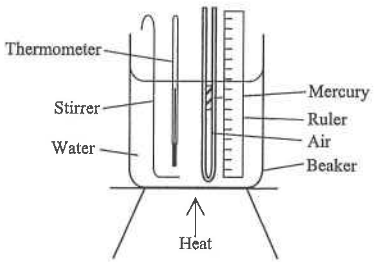
< thermometer > [1]

< Bourdon Gauge > [1]

Any **TWO** of the following : [2]

* Rubber tubing should be as short as possible.
* The flask should be fully immersed in water.
* Water must be well stirred before taking the reading of temperature.
* The thermometer should not touch the bottom of the beaker.
* Sufficient time must be allowed for the flask to be heated up.

3. (a)



[1]

Tie the tube against a ruler and put them into a beaker of water. [1]

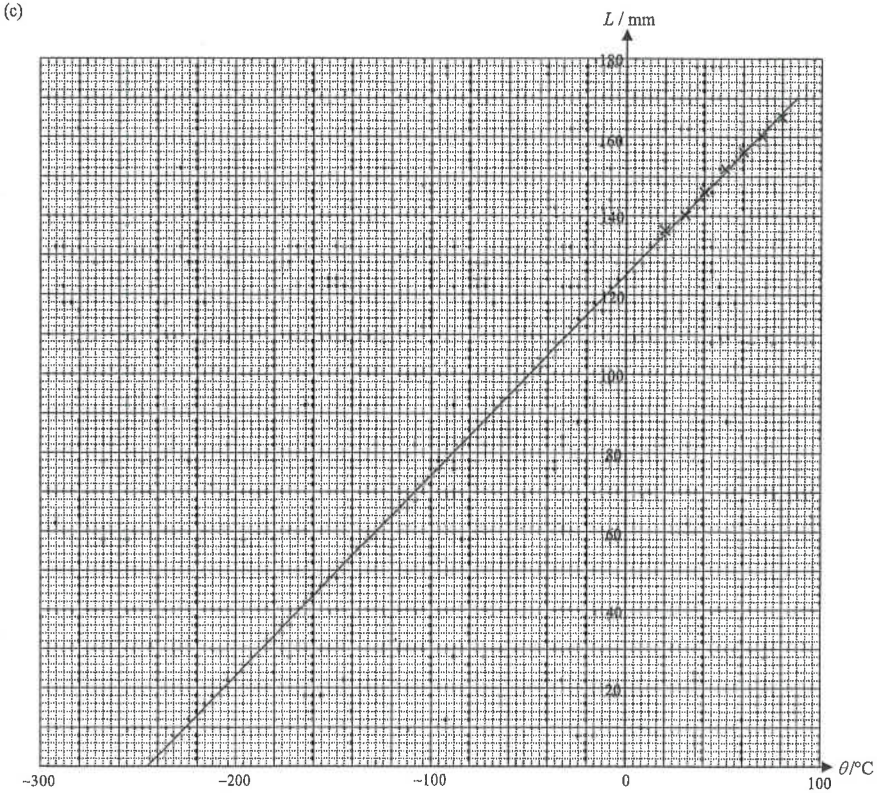
Heat the water gently. [1]

Record the temperature θ and the length L at certain temperature intervals. [1]

(b) Any **TWO** of the following : [2]

* The water must be well stirred to ensure uniform temperature before readings are taken.
* The air column should be completely immersed into the water.
* The thermometer and the tube should not touch the bottom of the beaker.
* Allow sufficient time for the air to reach the temperature of the water.

3. (c)



< correct label of axis and correct scale > [1]

< correct points plotted > [1]

< best fit line drawn > [1]

(d) Absolute zero = – 245°C < accept – 240°C to – 260°C > [2]

(e) $\dfrac{L}{\theta+245}$ = constant [2]

OR

$L \propto (\theta + 245)$ [2]

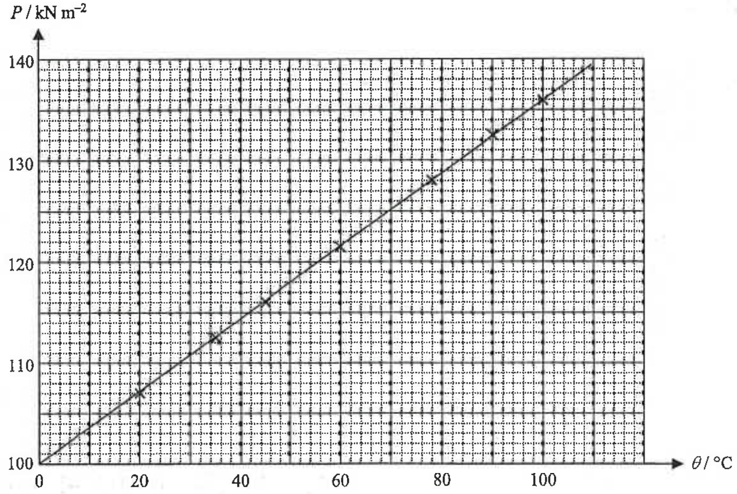
OR

$L \propto T$ where $T = \theta + 245$ [2]

(f) The pressure remains no change. [2]

Provided by dse.life

4. (a)



< correct label of 2 axes with units > [1]

< correct scale and range > [1]

< correct points plotted (0.5 marks each point, up to maximum of 2 marks) > [2]

< straight line drawn > [1]

(b) slope $= \dfrac{136-107}{100-20} = 0.36$ < from 0.34 to 0.38 is acceptable > [1]

P-intercept = 100 < from 98 to 102 is acceptable > [1]

The equation : $P = 0.36\,\theta + 100$

(c) From the graph, when $P = 118$;

$\theta = 50$°C [2]

OR

From the equation, put $P = 118$;

$\therefore$ $(118) = 0.36\,\theta + 100$

$\therefore$ $\theta = 50$°C [2]

(d) Any **THREE** of the following : [3]

* The flask should be completely immersed in water.
* The rubber tubing joining the flask and the Bourdon Gauge should be shorter.
* A stirrer should be used to stir the water.
* The thermometer should not touch the bottom of the beaker.
* The flask should not touch the bottom of the beaker.

5. (a) The length of the rubber tubing should be short [1]

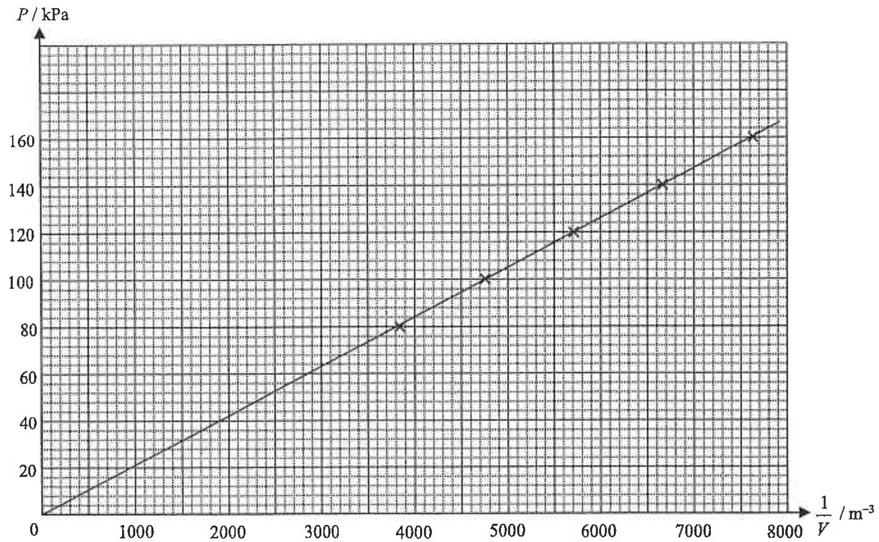
to reduce the volume of the gas inside the tubing. [1]

Any **TWO** of the following : [2]

* Move the piston slowly.
* Lubricate the piston.
* Do not take reading immediately after the piston is moved.

(b)

Pressure P / kPa	80	100	120	140	160
Volume V / m^3	2.60×10^{-4}	2.10×10^{-4}	1.75×10^{-4}	1.50×10^{-4}	1.31×10^{-4}
$\dfrac{1}{V}$ / m^{-3}	3850	4760	5710	6670	7630



< Labelled axes with units > [1]

< Appropriate scales > [1]

< Correct points plotted > [1]

< A suitable straight line drawn > [1]

The student is attempting to verify Boyle's Law. [1]

(c) $P_1 V_1 = P_2 V_2$ [1]

$(100) \times (1.8 \times 10^{-4} + V) = (210)\,(V)$ [1]

$\therefore$ $V = 1.64 \times 10^{-4}$ m^3 [1]

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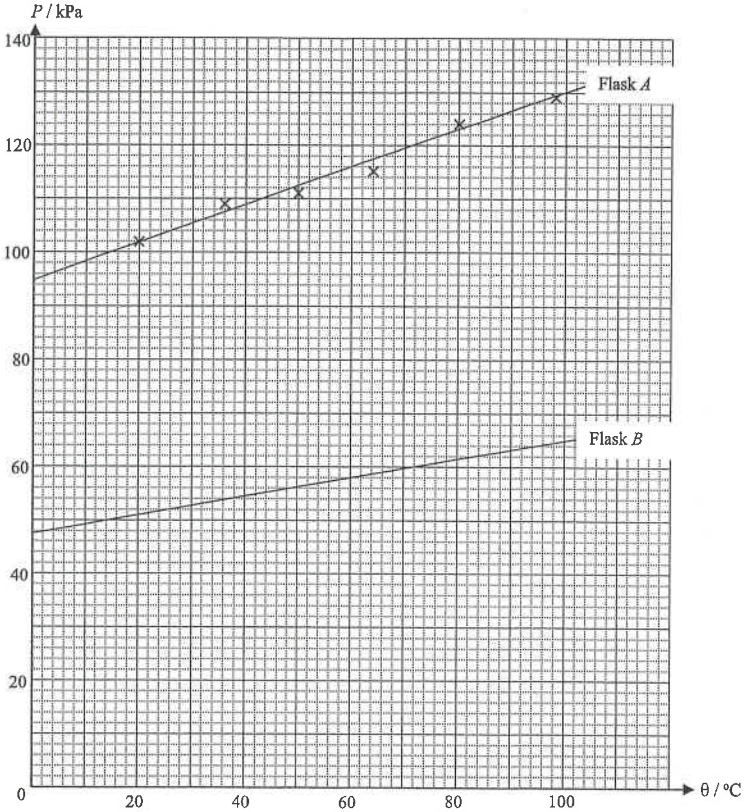
6. (a)



< Two labelled axes > [1]
< Correct scales > [1]
< Points correctly plotted > [1]
< A best fitted straight line drawn > [1]

(b) As the line does not pass through the origin, the pressure is not proportional to temperature. [1]
So David's conclusion is not correct. [1]

(c) Any **TWO** of the following : [2]

∗ Immerse the flask completely into the water. (**OR** Add some more water into the flask.)
∗ Stir the water throughout the experiment.
∗ Use a shorter rubber tubing. (**OR** Use a larger flask.)

(d) (i) $P_1 V_1 = P_2 V_2$ (For flask A, $P = 95$ kPa at 0°C) [1]
$(95)(V) = P_2(2V)$ $\therefore P_2 = 47.5$ kPa < from 46 to 49 is acceptable > [1]

(ii) < The pressure should be halved at the same temperature and the slope is also halved. > [1]

7. $\dfrac{P_1}{T_1} = \dfrac{P_2}{T_2}$ [1]

$\therefore \dfrac{200}{30+273} = \dfrac{P_2}{60+273}$ $\therefore P_2 = 220$ kPa [1]

8. (a) $L_1 = 4.7$ cm [1]

(b) By V-T relation : $V \propto L \propto T$ $\therefore \dfrac{L_1}{T_1} = \dfrac{L_2}{T_2}$

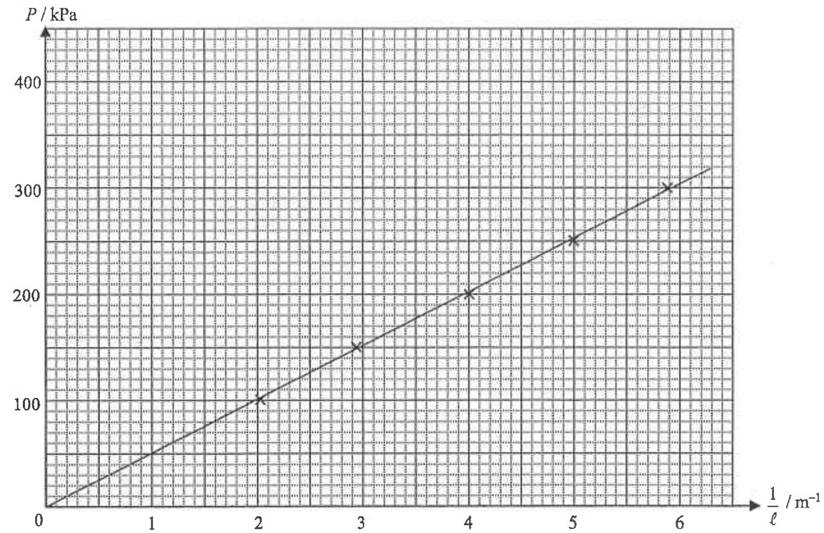
$\therefore \dfrac{4.7}{25+273} = \dfrac{L_2}{80+273}$ [1]

$\therefore L_2 = 5.57$ cm < accept 5.6 cm > [1]

Assume the pressure inside the air column is constant. [1]

9. (a)

Pressure P / kPa	100	150	200	250	300
Length of air column ℓ / m	0.49	0.34	0.25	0.20	0.17
$\dfrac{1}{\ell}$ / m^{-1}	2.04	2.94	4.00	5.00	5.88



< Correct labelled axes with units > [1]
< Appropriate scales > [1]
< Correct points plotted (at least 4 points) > [1]
< A straight line through the points > [1]

Conclusion : The pressure is inversely proportional to the volume. [1]

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9. (b) Any **ONE** of the following : [1]

- ✱ Press the foot pump slowly.
- ✱ Do not take readings immediately after the foot pump is pressed.
- ✱ After pressing the pump, wait for a while to ensure that the temperature becomes steady.

10. By $P V = n R T$

$\therefore\ (1.01 \times 10^5)\, V = (1) \times (8.31) \times (0 + 273)$

$\therefore\ V = 0.0225\ \text{m}^3$ [1]

$M = \rho V = (1.43) \times (0.0225) = 0.032\ \text{kg}$ < accept 0.0321 or 0.0322 kg > [1]

11. (a) $P V = n R T$

$\therefore\ (10^5)\, V_1 = (0.2) \times (8.31) \times (301)$

$\therefore\ V_1 = 5.00 \times 10^{-3}\ \text{m}^3$ [1]

By V-T relation :

$\therefore\ \dfrac{V_2}{400} = \dfrac{5.00 \times 10^{-3}}{301}$

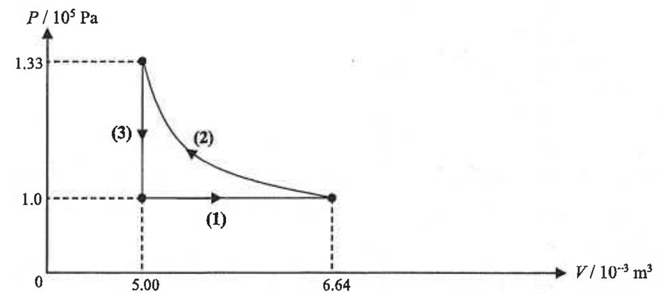
$\therefore\ V_2 = 6.64 \times 10^{-3}\ \text{m}^3$ [1]

(b) By Boyle's law :

$\therefore\ (1 \times 10^5) \times (6.64 \times 10^{-3}) = P \times (5.00 \times 10^{-3})$ [1]

$\therefore\ P = 1.33 \times 10^5\ \text{Pa}$ [1]

(c)



< Process (1) is horizontal > [1]

< Process (2) is a curve with constant temperature > [1]

< Process (3) is vertical > [1]

< Correct values indicated > [1]

12. (a) Remove the Bunsen burner to stop heating. [1]

Well stir the water with the stirrer to ensure uniform temperature. [1]

(b) (i) $\dfrac{65 - 20}{92 - 20} = \dfrac{L - 64}{80 - 64}$ [1]

$\therefore\ L = 74\ \text{mm}$ [1]

(ii) $\dfrac{20 - \theta}{92 - 20} = \dfrac{64 - 0}{80 - 64}$ [1]

$\therefore\ \theta = -268\ °\text{C}$ [1]

OR

$\dfrac{64}{20 - \theta} = \dfrac{80}{92 - \theta}$ [1]

$\therefore\ \theta = -268\ °\text{C}$ [1]

13. (a) $P_1 V_1 = P_2 V_2$

$(210) \times (1.0 \times 10^4) = (2) \times V_2$ [1]

$\therefore\ V_2 = 1.05 \times 10^6\ \text{cm}^3$ < accept $1.04 \times 10^6\ \text{cm}^3$ > [1]

(b) (i) $V_o = \dfrac{1.05 \times 10^6}{60} = 1.75 \times 10^4\ \text{cm}^3$ < accept $1.73 \times 10^4\ \text{cm}^3$ > [1]

(ii) $\dfrac{P_1 V_1}{T_1} = \dfrac{P_2 V_2}{T_2}$

$\therefore\ \dfrac{(210) \times (1.0 \times 10^4)}{(24 + 273)} = \dfrac{(4.5)\, V_2}{(20 + 273)}$ [1]

$\therefore\ V_2 = 4.604 \times 10^5\ \text{cm}^3$ < accept $4.50 \times 10^5\ \text{cm}^3$ > [1]

$\text{Time} = \dfrac{4.604 \times 10^5}{1.75 \times 10^4} = 26.3\ \text{min.}$ < accept 26.0 min > [1]

14. (a) By $P V = n R T$ [1]

$\therefore\ (1.0 \times 10^5)(6.0 \times 10^{-5}) = n\,(8.31)\,(25 + 273)$ [1]

$\therefore\ n = 2.42 \times 10^{-3}\ \text{mol}$

Number of molecules $= 2.42 \times 10^{-3} \times 6.02 \times 10^{23} = 1.46 \times 10^{21}$ [1]

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

- ✱ The process of pulling and pushing should be slow.
- ✱ Do not take readings immediately after moving the piston.

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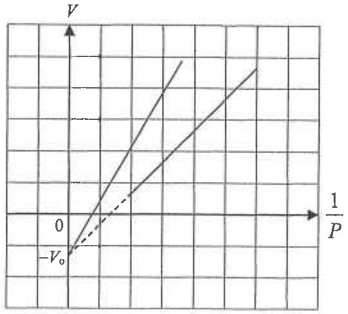
14. (b) (ii) V_0 represents the volume of gas inside the rubber tubing. [1]

(iii)



< same y-intercept > [1]

< greater slope > [1]

[By $P(V+V_0) = nRT$ $\therefore V = nRT\frac{1}{P} - V_0$ $\therefore$ slope $= nRT$]

15.

(a) $pV = nRT$		
$(100\times10^3)(0.52) = n(8.31)(273+15)$	1M	
$n = 21.727504$ (mol) ≈ 21.7 (mol)	1A	
		2
(b) (i) Since $pV = nRT \Rightarrow V = \frac{nRT}{p}$ /	1A	
volume V of the balloon depends on both T and p, the (fractional) decrease in pressure p (with height) is greater / faster than the (fractional) decrease in temperature T.	1A	
		2
(ii) (1) $\frac{pV}{T} = $ constant		
$\frac{(100)(0.52)}{(273+15)} = \frac{p(8)}{216}$.	1M	
$p = 4.875$ kPa or 4875 Pa	1A	
		2
(2) $p = p_0e^{-kx}$		
$4.875 = 100e^{-0.138x}$	1M	
$x = 21.89166726$ (km) ≈ 21.9 (km)	1A	
		2

Hong Kong Diploma of Secondary Education Examination

Physics – Compulsory part (必修部分)

Section A – Heat and Gases (熱和氣體)
1. Temperature, Heat and Internal energy (溫度、熱和內能)
2. Transfer Processes (熱轉移過程)
3. Change of State (形態的改變)
4. General Gas Law (普通氣體定律)
5. Kinetic Theory (分子運動論)

Section B – Force and Motion (力和運動)
1. Position and Movement (位置和移動)
2. Newton's Laws (牛頓定律)
3. Moment of Force (力矩)
4. Work, Energy and Power (作功、能量和功率)
5. Momentum (動量)
6. Projectile Motion (拋體運動)
7. Circular Motion (圓周運動)
8. Gravitation (引力)

Section C – Wave Motion (波動)
1. Wave Propagation (波的推進)
2. Wave Phenomena (波動現象)
3. Reflection and Refraction of Light (光的反射及折射)
4. Lenses (透鏡)
5. Wave Nature of Light (光的波動特性)
6. Sound (聲音)

Section D – Electricity and Magnetism (電和磁)
1. Electrostatics (靜電學)
2. Electric Circuits (電路)
3. Domestic Electricity (家居用電)
4. Magnetic Field (磁場)
5. Electromagnetic Induction (電磁感應)
6. Alternating Current (交流電)

Section E – Radioactivity and Nuclear Energy (放射現象和核能)
1. Radiation and Radioactivity (輻射和放射現象)
2. Atomic Model (原子模型)
3. Nuclear Energy (核能)

Physics – Elective part (選修部分)

Elective 1 – Astronomy and Space Science (天文學和航天科學)
1. The universe seen in different scales (不同空間標度下的宇宙面貌)
2. Astronomy through history (天文學的發展史)
3. Orbital motions under gravity (重力下的軌道運動)
4. Stars and the universe (恆星和宇宙)

Elective 2 – Atomic World (原子世界)
1. Rutherford's atomic model (盧瑟福原子模型)
2. Photoelectric effect (光電效應)
3. Bohr's atomic model of hydrogen (玻爾的氫原子模型)
4. Particles or waves (粒子或波)
5. Probing into nano scale (窺探納米世界)

Elective 3 – Energy and Use of Energy (能量和能源的使用)
1. Electricity at home (家居用電)
2. Energy efficiency in building (建築的能源效率)
3. Energy efficiency in transportation (運輸業的能源效率)
4. Non-renewable energy sources (不可再生能源)
5. Renewable energy sources (可再生能源)

Elective 4 – Medical Physics (醫學物理學)
1. Making sense of the eye (眼的感官)
2. Making sense of the ear (耳的感官)
3. Medical imaging using non-ionizing radiation (非電離輻射醫學影像學)
4. Medical imaging using ionizing radiation (電離輻射醫學影像學)

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