UNIVERSITY EXAMINATIONS

UNIVERSITEITSEKSAMENS

UNISA university of south africa

# PHY1506

May/June 2017

## ELECTROMAGNETISM AND HEAT (PHYSICS)

Duration : 2 Hours | 100 Marks

**EXAMINERS :**
FIRST : DR B MUKERU
SECOND : PROF BM MOTHUDI

**Use of a non-programmable pocket calculator is permissible.**

**Closed book examination.**



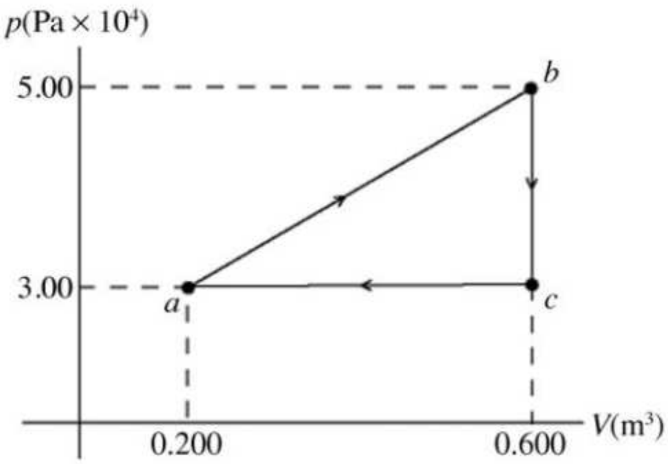
**INSTRUCTIONS:**

- **This paper consists of 5 pages.**
- **The paper consists of 6 questions for a total of 100 marks.**
- **Marks for each question or part are indicated in brackets on the right of the question.**
- **Show all the necessary steps in carrying out your calculations.**
- **The information given on page 4 maybe used without proof.**
- **Answer ALL questions.**

[TURN OVER]

## Question 1

The figure below represents a pV [$p$ in Pa $\times$ $10^4$ and $V$ in $m^3$] diagram for 7.50 moles of an ideal diatomic gas taken through the cycle $a \rightarrow b \rightarrow c$.




(a) Calculate the highest temperature reached by the gas during the cycle **(4)**

(b) What net work does the gas do during the cycle? **(4)**

(c) How much heat is exchanged with the gas during part $bc$ of the cycle? Does it enter or leave the gas? **(4)**

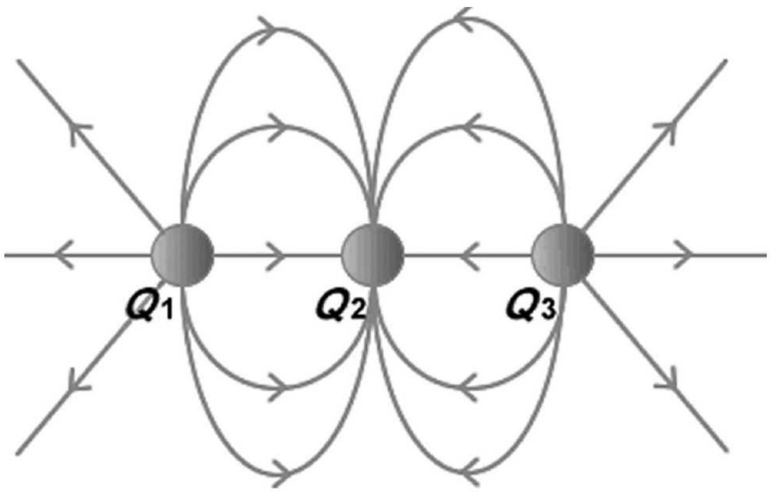
(d) What is the change in the internal (thermal) energy of the gas during part $bc$ of the cycle? **(4)**

(e) What is the change in the internal (thermal) energy of the gas during the entire cycle? **(4)**

**[20]**

## Question 2

(a) The figure below shows three electric charges labeled $Q_1$,$Q_2$,$Q_3$, and some electric field lines in the region surrounding the charges. What are the signs of the three charges? **(6)**




**[TURN OVER]**

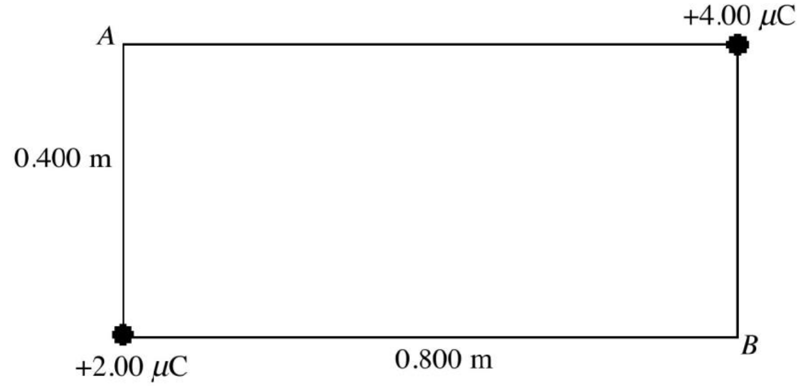
(b) A 400-g piece of metal at 120.0°C is dropped into a cup containing 450 g of water at 15.0°C. The final temperature of the system is measured to be 40.0°C. Calculate the specific heat of the metal, assuming no heat is exchanged with the surroundings or the cup. The specific heat of water is 4186 J/(kg.K). **(6)**

(c) Why doing a change of phase, heat is absorbed but the temperature does not rise? **(3)**

**[15]**

## Question 3

(a) Two positive point charges $+4.00\,\mu$C and $+2.00\mu$C are placed at the opposite corners of a rectangle as shown in the figure. What are the potentials at points $A$ and $B$ (relative to infinity) due to these charges? **(10)**




(b) A heat engine with an efficiency of 30.0% performs 2500 J of work. How much heat is discharged to the lower temperature reservoir? **(10)**

**[20]**

## Question 4

(a) The magnetic field of a moving charge is given by

$$\vec{\mathbf{B}} = \frac{\mu_0}{4\pi}\frac{\mathbf{qv}\sin\theta}{\mathbf{r^2}}.$$

(i) Which law does this equation represent? **(2)**

(ii) What do $r$,$\mu$,$v$ and $\theta$ represent? **(4)**

(b) What is an electromagnetic induction? **(3)**

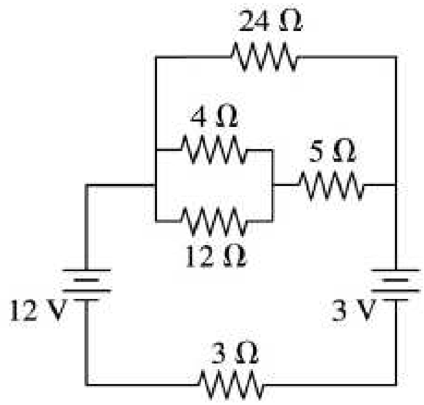
(c) State Faraday's law **(6)**

**[15]**

**[TURN OVER]**

## Question 5

Consider the electric circuit as shown in the figure below, find:




(a) the equivalent resistor of the circuit, **(5)**

(b) the current flowing through each resistor, **(8)**

(c) the potential difference across each resistor. **(7)**

**( Please summarize your results in a table for an easy reading)**

**[20]**

## Question 6

An RLC circuit consists of a $10\,\Omega$ resistor, a $1.0\,\text{mH}$ and a $1.0\,\mu F$ capacitor, in series and connected to a $(10V)\cos\omega t$. Calculate:

(a) the resonance frequency **(3)**,

(b) the resistor and capacitor voltages ($V_R$ and $V_C$). **(7)**

**[10]**

**TOTAL: 100 Marks**

**[TURN OVER]**

# FORMULAE

$PV = nRT$

$U_{\rm el} = \frac{kq}{r}$

$Q_C + W_{\rm out} = Q_H$

$R = R_1 + R_2$

$f = \frac{\omega}{2\pi}$

$V_R = IR$

$X_C = \frac{1}{\omega C}$

$Q_P = nC_P\Delta T$

$W = p\Delta V$

$\Delta E_{\rm th} = Q - W$

$\frac{P_iV_i}{T_i} = \frac{P_fV_f}{T_f}$

$Q = mC\Delta T$

$Q_H = \frac{W_{\rm out}}{\eta}$

$\frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2}$

$\omega = \frac{1}{\sqrt{LC}}$

$I = \frac{\varepsilon}{\sqrt{R^2+(X_L+X_C)^2}}$

$V_C = IX_C$

$Q_V = nC_V\Delta T$

$W = nRT\ln{(V_f/V_i)}$ (isothermal)

$\Delta E_{\rm th} = Q$

$\Delta E_{\rm th} = \eta C_V\Delta T$ (any process)

$E_{\rm th} = \frac{5}{2}nRT$ (diatomic gas)

# USEFUL INFORMATION

$k_B = 1.38 \times 10^{-23}$ J/K

$e = 1.60 \times 10^{-19}$ C

$K = 9.0 \times 10^9$ Nm$^2$/C$^2$

$C_V = \frac{5}{2}R, \quad C_P = \frac{7}{2}R$ (diatomic gas)

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

$R = 8.31$ J/mol.K

$1\,\mu$C $= 10^{-6}$ C

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