# **HWA CHONG INSTITUTION**



29 September 2009

50 minutes

Do not open this booklet until you are told to do so.

## **READ THESE INSTRUCTIONS FIRST**

Write in soft pencil.

Do not use staples, paper clips, highlighters, glue or correction fluid.

Complete the information on the optical mark sheet (OMS) as shown below.

1.	Enter your NAME ( as in NRIC ).	← Write your <b>name</b>	
2.	Enter the SUBJECT TITLE.		
3.	Enter the PAPER NUMBER.	Write your <b>CT group</b>	
4.	Enter your CT GROUP.		
5.	Date.	NRIC / FIN	[]
6. 7.	Enter your NRIC NUMBER or FIN NUMBER. Now SHADE the corresponding lozenge in the grid for EACH DIGIT or LETTER	S 0	Write <u>and</u> shade your NRIC or FIN number
		7 0 7 0 7 0 7 0 7 0 7 0 7 0 8 0 8 0 8 0	

There are **thirty** questions on this paper. Answer **all** questions. For each question, there are four possible answers **A**, **B**, **C** and **D**.

Choose the **one** you consider correct and record your choice in **soft pencil** on the OMS.

Each correct answer will score one mark. A mark will **not** be deducted for a wrong answer. Any rough working should be done in this booklet.

#### **Section A**

For each question there are four possible answers, **A**, **B**, **C** and **D**. Choose the **one** you consider to be correct.

**1** The relative abundances of the isotopes of a sample of titanium are shown in the table below.

Relative Isotopic Mass	46	47	48	49	50
Relative Abundance	11.2	10.1	100.0	7.3	7.0

What is the relative atomic mass of titanium in this sample?

<b>A</b> 4	7.92	В	47.91	С	47.90	D	47.89
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2 In the middle of the 15<sup>th</sup> century, 'black powder' was widely used by the Arabs as propellant for muzzle-loading cannons. 'Black powder' consisted of a mixture of potassium nitrate, sulfur and charcoal (carbon) in the molar ratio shown in the equation below.

 $2\text{KNO}_3 \text{ (s)} + \text{S (s)} + 3\text{C (s)} \rightarrow \text{K}_2\text{S (s)} + \text{N}_2 \text{ (g)} + 3\text{CO}_2 \text{ (g)}$ 

Given that 2.00 mol of gas could just expel the cannonball out of the cannon tube, what is the minimum mass of 'black powder' (in g), required for this to happen?  $[M_r: KNO_3, 101.1]$ 

- **3** Which of the following contains 1 mol of the stated particles?
  - **A** electrons in 1 g of hydrogen gas
  - **B** chlorine molecules in 35.5 g of chlorine gas
  - **C** oxygen atoms in 22.4 dm<sup>3</sup> of oxygen gas at s.t.p.
  - **D** hydrogen ions in 1 dm<sup>3</sup> of 1 mol dm<sup>-3</sup> aqueous sulfuric acid
- 4 The successive ionisation energies (IE) of two elements, **Q** and **R**, are given below.

IE / kJ mol <sup>-1</sup>	1 <sup>st</sup>	2 <sup>nd</sup>	3 <sup>rd</sup>	4 <sup>th</sup>	5 <sup>th</sup>	6 <sup>th</sup>	7 <sup>th</sup>	8 <sup>th</sup>
Q	1090	2350	4610	6220	37800	47000	-	-
R	1251	2298	3822	5158	6542	9362	11018	33604

What is the likely formula of the compound that is formed when **Q** reacts with **R**?

A QR B  $Q_2R_3$  C  $QR_4$  D  $Q_4R$ 

5 What is the electronic configuration of an atom of the element which is isoelectronic with  $H_2S$ ?

 $\begin{array}{lll} \textbf{A} & 1s^2\,2s^2\,2s^6\,3s^2 \\ \textbf{B} & 1s^2\,2s^2\,2s^6\,3s^2\,3p^2 \\ \textbf{C} & 1s^2\,2s^2\,2s^6\,3s^2\,3p^4 \\ \textbf{D} & 1s^2\,2s^2\,2s^6\,3s^2\,3p^6 \end{array}$ 

- **6** Which of the following statements about the properties associated with ionic and covalent
  - bonds is correct?
    - **A** Some covalent compounds can serve as electrolyte in water.
    - **B** lonic bonds and covalent bonds cannot both occur in the same compound.
    - **C** lonic compounds and metals can conduct electricity in both the solid and liquid states.
    - **D** Any covalent compounds that have both hydrogen and oxygen in its molecule can form intermolecular hydrogen bond.
- 7 Which of the following molecules will **not** form a hydrogen bond with another of its own molecules?

Α	CH₃CHO	С	CH₃OH
В	CH <sub>3</sub> NH <sub>2</sub>	D	$NH_3$

- 8 Which of the following best describes the change in the bond angle in water when the ion  $H_3O^+$  is formed?
  - **A** decreases to approximately 90°
  - **B** decreases to approximately 109°
  - **C** increases slightly
  - D increases to approximately 120°
- **9** The explosive nitroglycerin (C<sub>3</sub>H<sub>5</sub>N<sub>3</sub>O<sub>9</sub>) decomposes rapidly upon ignition or sudden impact according to the following equation:

 $4C_{3}H_{5}N_{3}O_{9}(l) \rightarrow 12CO_{2}(g) + 10H_{2}O(g) + 6N_{2}(g) + O_{2}(g) \qquad \Delta H^{e}_{r} = -5678 \text{ kJ mol}^{-1}$ 

Given the following data, what is the standard enthalpy change of formation of nitroglycerin in kJ  $mol^{-1}$ ?

Standard enthalpy change of formation of  $CO_2(g) = -394 \text{ kJ mol}^{-1}$ Standard enthalpy change of formation of  $H_2O(g) = -242 \text{ kJ mol}^{-1}$ 

Α	-368	С	-3207
В	-1470	D	+5042

10 What is the value of the enthalpy change for the following process equal to?

$$Na(s) \rightarrow Na^{+}(g) + e^{-}$$

- A the first ionisation energy of sodium
- **B** the enthalpy change of vaporisation of sodium
- **C** the sum of the first ionisation energy and the electron affinity of sodium
- **D** the sum of the enthalpy change of atomisation and the first ionisation energy of sodium
- **11** The bromination of propanone is acid-catalysed.

$$CH_{3}COCH_{3} + Br_{2} \xrightarrow{H^{+}} CH_{3}COCH_{2}Br + H^{+} + Br^{-}$$

The rate of disappearance of the bromine colour was measured for several different concentrations of propanone, bromine and  $H^+$  at a certain temperature and the results tabulated below.

Experiment	[CH <sub>3</sub> COCH <sub>3</sub> ]/ mol dm <sup>-3</sup>	[Br <sub>2</sub> ]/ mol dm <sup>-3</sup>	[H <sup>+</sup> ]/ mol dm <sup>−3</sup>	Rate of disappearance of $Br_2$ colour/ mol dm <sup>-3</sup> s <sup>-1</sup>
1	0.30	0.05	0.05	5.70 x 10 <sup>-5</sup>
2	0.30	0.10	0.05	5.70 x 10 <sup>-5</sup>
3	0.30	0.05	0.10	1.14 x 10 <sup>-4</sup>
4	0.40	0.05	0.20	3.04 x 10 <sup>-4</sup>

Which of the following statements about the above reaction is true?

- **A** The rate equation for the reaction is rate = k[CH<sub>3</sub>COCH<sub>3</sub>][Br<sub>2</sub>].
- **B** The rate constant for the reaction is  $3.8 \times 10^{-3} \text{ mol}^{-1} \text{ dm}^3 \text{ s}^{-1}$ .
- **C** The rate constant of the reaction doubles when  $[CH_3COCH_3]$  is doubled.
- **D** The rate constant of the reaction remains unchanged when temperature is doubled.
- 12 Two experiments, **M** and **N**, were carried out to investigate the rates of the reaction between copper(II) carbonate and excess acid. The initial mass of the reaction vessel plus contents was the same in both experiments. The results are shown in the diagram below.



Which of the following change in the conditions from Experiment  $\mathbf{M}$  to Experiment  $\mathbf{N}$  might explain the results shown?

- A increasing the concentration of the acid
- **B** increasing the mass of copper(II) carbonate
- **C** decreasing the particle size of the copper(II) carbonate
- D adding a catalyst

**13** Phosgene,  $COCl_2$ , is a poisonous gas used as a chemical weapon in World War I. It can dissociate into two other poisonous gases, carbon monoxide and chlorine, at high temperatures according to the equilibrium below:

 $COCl_2(g) = CO(g) + Cl_2(g)$ 

When 1 mol of phosgene is heated in a closed vessel at 600 K, the final pressure at equilibrium was 5 atm. Given that the mole ratio of phosgene to chlorine at equilibrium is 15:2, what is the numerical value of  $K_p$  at 600 K?

- **A** 0.0140 **B** 0.0157 **C** 0.0702 **D** 0.0784
- 14 A solution of an acid E has the same pH as a solution of acid F. Equal dilution increases the pH of acid E more than that of acid F. Which of the following pairs of acids would show this behaviour?

	E	F
Α	H <sub>3</sub> PO <sub>4</sub>	HC <i>l</i>
В	HC <i>l</i>	CH <sub>3</sub> CO <sub>2</sub> H
С	HC <i>l</i>	$H_2SO_4$
D	CH <sub>3</sub> CO <sub>2</sub> H	$H_2SO_4$

**15** The graphs below show the variation in two properties of the elements Na to P and their compounds.



Which properties are illustrated in Graphs I and II?

#### Graph I

- **A** electrical conductivity of the element
- **B** electrical conductivity of the element
- **C** melting point of the element
- **D** melting point of the element

Graph II pH of the chloride when added to water pH of the oxide when added to water pH of the chloride when added to water pH of the oxide when added to water **16 X**, **Y** and **Z** are elements in Period 3 of the Periodic Table.

A mixture containing the oxides of X, Y and Z was dissolved in excess dilute sulfuric acid and filtered. The oxide of Z was collected as a residue. When excess dilute sodium hydroxide was added to the filtrate, only a white precipitate of the hydroxide of Y was formed.

What are the possible identities of X, Y and Z?

	Х	Y	Z
Α	Al	Mg	Р
В	Mg	Al	Р
С	Al	Mg	Si
D	Mg	Al	Si

**17** An element **Q** has a low proton number. It forms an amphoteric oxide and a chloride which, when anhydrous, is readily hydrolysed in water.

Which Group in the Periodic Table might contain **Q**?

Α	11	С	IV
В	111	D	V

18 Which formula could represent a compound which has *geometrical* isomers?

Α	$C_2H_6O_2$	С	$C_2H_2Cl_2$
В	$C_2H_2O_4$	D	$C_2H_3Cl$

**19** Which of the following compounds will **not** be produced when propene reacts with a mixture of Br<sub>2</sub> in aqueous NaC*l*?



**20** During electrophilic substitution on a benzene ring, the position of the incoming group, the new substituent, is determined by the nature of the group(s) already present in the ring. The directing effects of these groups are shown in the table below.

Directing Effects	3 – directing	2,4 – directing
Functional Groups with these effects	–NO <sub>2</sub> , –CO <sub>2</sub> H,	–CH <sub>3</sub> , –NH <sub>2</sub> , –X (halogens)

Compound **V** may be synthesised from benzene.



Which of the following synthetic routes will yield compound **V**?

- A Nitration  $\rightarrow$  alkylation  $\rightarrow$  reduction  $\rightarrow$  bromination  $\rightarrow$  oxidation
- **B** Alkylation  $\rightarrow$  nitration  $\rightarrow$  oxidation  $\rightarrow$  bromination  $\rightarrow$  reduction
- $\textbf{C} \qquad \text{Bromination} \rightarrow \text{nitration} \rightarrow \text{reduction} \rightarrow \text{alkylation} \rightarrow \text{oxidation}$
- **D** Nitration  $\rightarrow$  reduction  $\rightarrow$  bromination  $\rightarrow$  alkylation  $\rightarrow$  oxidation
- 21 The table below shows the rate of hydrolysis of the halogen-containing compounds P to S. The rate of hydrolysis is measured by the speed at which the silver halide precipitate is formed.

Р	Q	R	S
	CH <sub>2</sub> Cl	CH <sub>2</sub> Br	CH <sub>2</sub> I
No precipitate formed with prolonged heating with ethanolic AgNO <sub>3</sub> .	Precipitate formed after 10 minutes of heating reaction mixture with ethanolic AgNO <sub>3</sub> .	Precipitate formed after 2 minutes of warming reaction mixture with ethanolic AgNO <sub>3</sub> .	Precipitate forms instantaneously with ethanolic AgNO <sub>3</sub> .

Which statement explains the rate of reaction?

- A The C–X bond length increases from compound **P** to **S**.
- **B** The solubility of the compounds increases from **P** to **S**.
- **C** The mechanism for the reaction changes from **P** to **S**.
- **D** The reaction conditions are increasingly milder from **P** to **S**.
- 22 Which of the following isomers of  $C_5H_{12}O$  gives, on complete dehydration, the greatest number of different alkenes?
  - **A**  $CH_3CH_2CH(CH_3)CH_2OH$
  - **B**  $CH_3CH_2CH_2CH(OH)CH_3$
  - C CH<sub>3</sub>CH(CH<sub>3</sub>)CH<sub>2</sub>CH<sub>2</sub>OH
  - D C(CH<sub>3</sub>)<sub>3</sub>CH<sub>2</sub>OH

23 *Acarol* is sold as an insecticide for use on fruit and vegetables.



Acarol

The final stage in its manufacture is an esterification reaction.

Which alcohol is used in the final stage to form Acarol?

Α	di(4-bromophenyl)methanol	С	propan-1-ol
В	methanol	D	propan-2-ol

- **24** A compound **U** has all the following properties:
  - It is neutral.
  - It gives a silver mirror with Tollens' reagent.
  - It decolourises a hot aqueous solution of acidified KMnO<sub>4</sub> with evolution of CO<sub>2</sub> gas.

What could **U** be?



**25** Glucose can be represented by the formula  $CH_2OH(CHOH)_4CHO$ .

How many moles of ethanoyl chloride would react with one mole of glucose?

Α	1	С	4
В	2	D	5

### Section B

For each of the questions in this section, one or more of the three numbered statements **1** to **3** may be correct.

Decide whether each of the statements is or is not correct (you may find it helpful to put a tick against the statements you consider to be correct).

The responses **A** to **D** should be selected on the basis of

Α	В	С	D
1, 2 and 3	1 and 2 only	2 and 3 only	1 only
are correct	are correct	are correct	is correct

No other combination of statements is used as a correct response.

- **26** Which of the following statements is true about NaHF<sub>2</sub>?
  - **1** NaHF<sub>2</sub> conducts electricity in the molten state.
  - **2** The  $HF_2^-$  ion contains two covalent bonds.
  - **3** The shape of the anion is bent.
- 27 Which of the following have the same value as the standard enthalpy change of formation of carbon monoxide?
  - **1** <sup>1</sup>/<sub>2</sub> ΔH<sub>f</sub> <sup>2</sup>(CO<sub>2</sub>)
  - $2 \qquad \Delta H_{f'}(CO_2) \Delta H_{c'}(CO)$
  - $\mathbf{3} \qquad \Delta H_{c'}(C) \Delta H_{c'}(CO)$
- 28 Which of the following could act as acidic buffers?
  - 1 A 1:2 mixture of HCl and CH<sub>3</sub>CO<sub>2</sub>Na
  - **2** A 1:2 mixture of NaHCO<sub>3</sub> and Na<sub>2</sub>CO<sub>3</sub>
  - **3** A 1:2 mixture of NaOH and NH<sub>4</sub>C*l*
- **29** Which statements about the complete combustion of an alkene,  $C_nH_{2n}$  in oxygen are correct?
  - 1 The volume of oxygen required is directly proportional to the number of carbon atoms present in the molecule.
  - **2** The volume of gas produced at 25 °C is the same as for the complete combustion of an alkane with the same number of carbon atoms per molecule.
  - **3** At 120 °C, the volume of steam produced is always twice the volume of carbon dioxide.

The responses A to D should be selected on the basis of

Α	В	С	D
1, 2 and 3	1 and 2 only	2 and 3 only	1 only
are correct	are correct	are correct	is correct

No other combination of statements is used as a correct response.

30 The structure of compound **F** is shown below.



Which of the following statements about the reactions of F is true?

- 1 mol of **F** reacts with  $SOCl_2$  releases 2 mol of HCl gas. 1
- 2
- 1 mol of **F** reacts with Na metal releases 2 mol of  $H_2$  gas. 1 mol of **F** reacts with Na<sub>2</sub>CO<sub>3</sub> releases 2 mol of CO<sub>2</sub> gas. 3