

# JAMES COOK UNIVERSITY

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### SCHOOL OF PHARMACY AND MOLECULAR SCIENCES **Chemistry Department**

This paper must be handed in at the end of the Examination: Yes **Release to Library:** 

THREE (3) HOURS

**TWENTY (20) MINUTES** 

Yes

# **FIRST SEMESTER EXAMINATIONS 2003**

## **Cairns Campus**

**STUDENT NAME:** (block letters)

**STUDENT NUMBER:** 

**SUBJECT CODE:** CH1011:03

**SUBJECT NAME:** CHEMISTRY FOR THE NATURAL SCIENCES

**EXAMINER:** Dr M. Liddell **PHONE NO:** (07) 4042 1275

**DURATION OF EXAMINATION (hours):** 

**PERUSAL TIME (minutes):** 

TOTAL NUMBER OF QUESTIONS: 40

### **INSTRUCTIONS TO STUDENTS:**

The exam is composed of two sections: Section A - Multiple choice - 32 questions - 32% Section B - Short answer - 8 questions - 68% Answer ALL questions. Total marks for paper = 100All questions are **not** of equal value.

MATERIALS TO BE SUPPLIED BY EXAMINATION SECTION:

Examination Booklets required: Yes Multiple choice scanner sheets: Yes Equation List Tables 1 and 2 Periodic Table

## MATERIALS STUDENTS MAY USE: Any type of calculator.

Access to an English Dictionary: Yes

# **SECTION A**

### MULTIPLE CHOICE QUESTIONS (EACH QUESTION IS WORTH ONE (1) MARK). ANSWER ALL QUESTIONS - SHADE WITH A PENCIL THE MOST CORRECT ANSWER ON THE MULTICHOICE SCANNER SHEET.

1. Which one of the following has the element name and symbol correctly matched?

- (a) P, potassium
- (b) C, copper
- (c) Mg, manganese
- (d) Ag, silver
- (e) Sn, silicon
- 2. Which of the following is a physical property of sodium chloride?
- (a) It is a solid at room temperature.
- (b) It has low volatility at room temperature.
- (c) It melts at a very high temperature.
- (d) It is not significantly compressible.
- (e) All of these are physical properties of sodium chloride
- 3. How many grams of H<sub>3</sub>PO<sub>4</sub> are in 175mL of a 3.5 M solution of H<sub>3</sub>PO<sub>4</sub>?
- (a) 0.61
- (b) 60
- (c) 20
- (d) 4.9
- (e) 612

### 4. The simplest amino acid is

- (a) alanine
- (b) valine
- (c) histidine
- (d) lycine
- (e) glycine

### 5. Which one of the following atoms has the largest radius?

- (a) O
- (b) F
- (c) S
- (d) Cl
- (e) Ne

### 6. What is the maximum number of electrons that can be contained in the third shell?

- (a) 8
- (b) 18
- (c) 2
- (d) 4
- (e) 32

7. What is the size of the H-C-H angle in methane?

(a) 109.0°

- (b) 109.5°
- (c) 105.0°
- (d) 105.9°
- (e) 159.0°

**8.** Which of the following compounds will have **hydrogen bonds** as one of its intermolecular forces? (HF, NH<sub>3</sub>, SiH<sub>4</sub>, CH<sub>4</sub>)

- (a)  $HF and NH_3$
- (b)  $SiH_4$  only
- (c)  $CH_4$  only
- (d)  $NH_3$  only
- (e) HF only
- 9. CFC stands for
- (a) chlorinated freon compound
- (b) chlorofluorocarbon
- (c) carbonated fluorine compound
- (d) caustic fluorine carbohydrate
- (e) carbofluoro compound

10. The formula of hydrobromic acid is \_\_\_\_\_\_.

- (a) HBr
- (b) HBrO<sub>4</sub>
- (c) HBrO
- (d) HBrO<sub>3</sub>
- (e) HBrO<sub>2</sub>

11. Crystalline solids differ from amorphous solids in that crystalline solids have \_\_\_\_\_\_.

- (a) appreciable intermolecular attractive forces
- (b) a long-range repeating pattern of atoms, molecules, or ions
- (c) atoms, molecules, or ions that are close together
- (d) much larger atoms, molecules, or ions
- (e) no orderly structure
- **12.** What is the coefficient of Al when the following equation is **balanced** with integer coefficients? Al + H<sub>2</sub>O  $\leftrightarrows$  Al(OH)<sub>3</sub> + H<sub>2</sub>
- (a) 1
- (b) 2
- (c) 3
- (d) 5
- (e) 4

13. When a hydrocarbon is combusted in air, what component of air reacts?

- (a) oxygen
- (b) nitrogen
- (c) carbon dioxide
- (d) water
- (e) argon

### 14. What is the molecular weight (amu) of the compound C<sub>2</sub>H<sub>5</sub>OH?

- (a) 34
- (b) 41
- (c) 30

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(d) 46

(e) 92

**15.** The **pressure** in a 12.2 L vessel that contains 2.34 g of carbon dioxide, 1.73 g of sulfur dioxide, and 3.33 g of argon, all at 42°C is \_\_\_\_\_ torr.

(a) 263

- (b) 134
- (c) 395
- (d) 116
- (e) 0.347

16. Which structure below represents a ketone?



- (d) structure d
- (e) structure e

**17.** What mass (in grams) of NO<sub>2</sub> can be produced by **combustion** of 43.9 g of ammonia? Be sure to balance the reaction.  $NH_3 + O_2 \qquad \leftrightarrows \qquad NO_2 + H_2O$ 

- (a) 2.58
- (b) 178
- (c) 119
- (d) 0.954
- (e) 43.9

**18.** A 25.5 g piece of cheddar cheese contains 37% fat, 28% protein, and 4% carbohydrate. The respective fuel values (in kJ/g) for fat, protein, and carbohydrate are 38, 17, and 17, respectively. What is the **fuel value** (in kJ) for this piece of cheese?

- (a) 500
- (b) 330
- (c) 790
- (d) 99
- (e) 260

**19. Le Chatelier's Principle** predicts which action(s) below to cause the endothermic reaction  $CH_3CH=CH_2(g) \stackrel{\leftarrow}{\rightarrow} C_3H_6(g)$ 

to form more CH<sub>3</sub>CH=CH<sub>2</sub> than initially present at equilibrium?

- (a) increasing the system temperature
- (b) decreasing the system temperature
- (c) increasing the system pressure
- (d) decreasing the system pressure
- (e) decreasing <u>both</u> the system temperature <u>and</u> the system pressure

20. In which of the following aqueous solutions would you expect AgCl to have the lowest solubility?

- (a) pure water
- (b)  $0.020 \text{ M BaCl}_2$
- (c) 0.015 NaCl
- (d)  $0.020 \text{ AgNO}_3$
- (e) 0.020 KCl
- **21.** What is the **conjugate acid** of NH<sub>3</sub>?
- (a) NH<sub>3</sub>
- (b)  $NH_2^+$
- (c)  $NH_3^+$
- (d)  $NH_4^+$
- (e) NH<sub>4</sub>OH

22. What is the **pH** of a 0.015 M solution of barium hydroxide?

- (a) 12.48
- (b) 12.18
- (c) 1.82
- (d) 10.35
- (e) 1.52

23. The standard free energy of formation of \_\_\_\_\_\_ is zero.

- (a)  $H_2O(l)$
- (b) Br<sub>2</sub>(s)
- (c) O(g)
- (d)  $N_2(g)$
- (e)  $N_2(g)$  and O(g)

24. Which equation represents a reaction that is decreasing in entropy as the reaction proceeds?

 $\begin{array}{lll} (a) & CaCO_3(s) & \leftrightarrows CaO(s) + CO_2(g) \\ (b) & 2C(s) + O_2(g) & \leftrightarrows 2CO(g) \\ (c) & 2Na(s) + 2H_2O(l) & \leftrightarrows 2NaOH(aq) + H_2(g) \\ (d) & 2H_2(g) + O_2(g) & \leftrightarrows 2H_2O(l) \\ (e) & H_2O(l) & \leftrightarrows H_2O(g) \end{array}$ 

25. \_\_\_\_\_\_ is **reduced** in the following reaction.

$$Cr_{2}O_{7}{}^{2\text{-}}+6S_{2}O_{3}{}^{2\text{-}}+14H^{+}\ \leftrightarrows\ 2Cr^{3+}+3S_{4}O_{6}{}^{2\text{-}}+7H_{2}O_{6}{}^{2\text{-}}+2H_{2}O_{6}{}+2H_{2}O_{6}{}+2H_{2}O_{6}{}+2H_{2}O_{6}{}+2H_{2}O_{$$

 $\begin{array}{rl} (a) & Cr_2O_7^{2-} \\ (b) & S_2O_3^{2-} \\ (c) & H^+ \\ (d) & Cr^{3+} \\ (e) & S_4O_6^{-2-} \end{array}$ 

26. What is the oxidation state of manganese in manganese dioxide?

- (a) +3(b) +2
- (c) +1
- (d) +4 (e) +7

### **27.** The **electrode** at which **oxidation** occurs is called the

- (a) oxidizing agent
- (b) cathode
- (c) reducing agent
- (d) anode
- (e) voltaic cell

### 28. Cathodic protection of a metal pipe against corrosion usually entails

- (a) attaching an active metal (easily oxidized) to make the pipe the anode in an electrochemical cell
- (b) coating the pipe with another metal whose standard reduction potential is less negative than that of the pipe
- (c) attaching an active metal (easily oxidized) to make the pipe the cathode in an electrochemical cell
- (d) attaching a dry cell to reduce any metal ions which might be formed
- (e) coating the pipe with a fluoropolymer to act as a source of fluoride ion (since the latter is so hard to oxidize)
- 29. What is meant by the salinity of seawater?
- (a) percent by mass of salt in seawater
- (b) mass in grams of dry salts present in 1 kg of seawater
- (c) molality of NaCl in seawater
- (d) osmotic pressure of seawater
- (e) molarity of NaCl in seawater

**30.** The solubility of oxygen gas in water at  $25^{\circ}$ C and 1.0 atm pressure of oxygen is 0.041 g/L. The **solubility of oxygen** in water at 3.0 atm and  $25^{\circ}$ C is \_\_\_\_\_ g/L.

- (a) 0.041
- (b) 0.014
- (c) 0.31
- (d) 0.12
- (e) 3.0

31. The layer of the atmosphere that contains our weather is called the \_\_\_\_\_\_.

- (a) mesosphere
- (b) heterosphere
- (c) stratosphere
- (d) thermosphere
- (e) troposphere

### 32. What is the **final stage** in municipal water treatment?

- (a) filtration through sand and gravel
- (b) aeration
- (c) settling
- (d) treatment with ozone or chlorine
- (e) removal of added fluoride

(3 marks)

# **SECTION B**

# SHORT ANSWER QUESTIONS. (MARKS FOR EACH QUESTION ARE AS INDICATED) ANSWER EACH OF THE EIGHT (8) QUESTIONS.

# **Question 1**

(a)	•	Describe the atomic structure of a <b>metallic solid</b> such as copper. How are the <b>physical properties</b> of copper related to the structure of t	he solid. (2 marks)
(b)	Using a •	acetic acid as an example illustrate the features of an <b>intermolecular hyd</b> What <b>physical properties</b> of acetic acid are influenced by hydrogen be	<b>lrogen bond</b> . onding? (2 marks)
(c)	(i)	<ul> <li>Provide systematic names for the following compounds:</li> <li>Ca(HCO<sub>3</sub>)<sub>2</sub></li> <li>Br<sub>2</sub>O<sub>7</sub></li> </ul>	
	(ii)	<ul><li>Provide a formula for the following compound:</li><li>ruthenium(II) oxide</li></ul>	(3 marks)
Que	stion 2		
(a)	Provide	<ul> <li>e electronic configurations for the following:</li> <li>O<sup>O</sup></li> <li>Cu</li> </ul>	(2 marks)
(b)	Provide	<ul> <li>brief reasoning in your answers to the following questions :</li> <li>Which is the larger ion in the following pair? Li<sup>+</sup> and Na<sup>+</sup>.</li> <li>Provide a definition for the ionization energy of Na.</li> </ul>	(2 marks)
(c)	Provid	le a "Lewis-dot" structure and use VSEPR Theory to predict electronic	

- and molecular geometries for: [OCl<sub>3</sub>]<sup>+</sup>
  Is this molecule likely to be **polar**, explain why or why not?
  - N.B. electronegativity: O 3.5, Cl 3.0

- (a) *Cocaine* was once used as an anesthetic.
  - Copy the structure into your answer book and identify and name all the **functional groups** present in *Cocaine*.
  - What class of amine is this molecule?

(2 marks)

## Cocaine





(i)

### Give an **IUPAC name** for the following compound:



(ii) Draw a **3D** *molecular structure* corresponding to the following systematic name :
 (S)-2-methylbutanal

(4 marks)

- (c) Briefly discuss ONE of the following topics. [In most cases your answer should consist of a few sentences together with any appropriate chemical structures]
  - (i) Amylose is a **polysaccharide** formed by the linking of multiple **monosaccharides**, in the cellular situation there is a considerable osmotic advantage gained from the high molecular weight of amylose.
  - (ii) **Proteins** are polymers of amino acids with well defined **secondary structures** that contribute to molecular function.
  - (iii) **Soaps** are fatty acid salts which are successful in solubilising oils because of their hydrophilic/.hydrophobic character in water.

(3 marks)

(i)

(b)

•

- The Ideal Gas equation is widely used for predicting the physical properties of gases under (a) ambient conditions.
  - Write down the Ideal Gas equation including the units.
  - What is Standard Temperature and Pressure (STP)? •

- The molal freezing point constant (K<sub>f</sub>) of water is 1.86 K kg solvent/mol solute. What would be the approximate freezing point of a solution of 0.10 mol/kg barium chloride (BaCl<sub>2</sub>), assuming complete dissociation?
- Using examples illustrate the differences between "hypertonic" and "hypotonic" (ii) solutions. Include definitions of osmotic pressure and water potential in your answer.
- In the reaction between iodoethane and the hydroxide anion the rate constant is  $k = 5.03 \times 10^{-2}$ (c)  $dm^3 mol^{-1} s^{-1}$  at 298K, at the higher temperature of 333K k = 6.71 dm<sup>3</sup> mol<sup>-1</sup> s<sup>-1</sup>.

 $C_2H_5I+OH^{\Theta} \ \ \ \rightarrow \ \ C_2H_5OH+I^{\Theta}$ 

- What is the activation energy of the reaction?
- What is the **rate constant** at 315K?

(3 marks)

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(2 marks)

(3 marks)

# **Question 5**

(a) Enzymes are large globular proteins which function as biological catalysts.

- How does an enzyme function as a catalyst? •
- Using an example illustrate the typical action of an enzyme. .
- What are two environmental factors that are important in maintaining the activity • of the enzyme?
- Radon is formed in granitic rocks according to the following scheme. (b)  $^{226}_{88}$ Ra  $\rightarrow ^{222}_{86}$ Rn
  - This process involves  $\alpha$ -decay. Balance the scheme demonstrating the principles of conservation of atomic number and conservation of mass number.
  - Why are there health problems associated with the formation or radon?

Stable isotope measurements are widely used in ecology, palaeoclimatology and physiology. (c)  $\delta^{18}$ O measurements from ice-cores have been used to establish the climatic conditions (global temperature) during the period of the last glacial-interglacial transition.

- Using the formula below explain how  $\delta^{18}$ O values are obtained.
- How can  $\delta^{18}$ O measurements establish global temperature change?

$$\delta^{18}O = \left(\frac{{}^{18}O/{}^{16}O_{sample} - {}^{18}O/{}^{16}O_{standard}}{{}^{18}O/{}^{16}O_{standard}}\right) \times 1000$$

(3 marks)

(3 marks)

(3 marks)

(a) Given the data below calculate  $\Delta H^{o}$  for the reaction.

> $SO_2(g) + \frac{1}{2}O_2(g) + H_2O(g)$  $H_2SO_4(1)$  $\Delta H_{\rm f}^{\rm o} / kJ \, {\rm mol}^{-1}$ Compound  $SO_2(g)$ -296.8 -285.8  $H_2O(1)$  $H_2O(g)$ -241.8 249.2 O(g)-814.0

> > (2 marks)

(b) (i) Balance the following chemical reaction. .

 $H_2SO_4(1)$ 

+ O<sub>2</sub>(g)  $CO_2(g) + H_2O(g)$  $C_3H_8(g)$  $\rightarrow$ 

- Predict whether entropy increases or decreases and explain why. •
- The use of metallic aluminium as a reducing agent is effective for the reduction of (ii) the oxides of many other metals, the thermite reaction is a good example:

 $2Al(s) + Fe_2O_3(s) \rightleftharpoons 2Fe(s) + Al_2O_3(s)$ 

- By using the sign of the standard free energy change as a criterion, decide • which of the following oxides, ZnO and MgO, cannot be reduced by aluminium.
- How does the magnitude of the standard free energy change determine the position of the equilibrium in the above reaction?

Compound	$\Delta G_{f}^{o} / kJ mol^{-1}$
ZnO (s)	-318.2
MgO(s)	-569.0
$Al_2O_3(s)$	-1582.0

(4 marks).

Identify the oxidising agent and reducing agent in the following redox reaction. (c)

> $Ca_{(s)} + NO_3^{\Theta}_{(aq)} \rightarrow Ca^{2+}_{(aq)} +$  $N_{2(g)}$ (2 marks)

(d) The cell voltage of the following cell at 298K was found to be +0.112 V. The cathodic electrode may be used as a hydroxyl sensing electrode.

> Cu<sub>(s)</sub>  $\begin{array}{c|c} Cu^{2+}{}_{(aq)} \\ \hline [0.01M] \end{array} \quad \left| \begin{array}{c} water sample \\ \hline [OH^{\Theta}] = ?? \end{array} \right| \quad HgO_{(s)}$ Hg<sub>(l)</sub>

- What is the overall cell reaction? •
- Calculate the standard cell potential  $\mathbf{E}^{o}_{cell}$ . •
- Calculate the **pOH** of the water sample. .

**Data:** 
$$HgO_{(s)} + H_2O_{(l)} + 2e^{\Theta} \rightarrow Hg_{(l)} + 2OH^{\Theta}_{(aq)}$$
  $E^{\circ} = +0.098 V$   
 $Cu^{2+}_{(aq)} + 2e^{\Theta} \rightarrow Cu_{(s)}$   $E^{\circ} = +0.340 V$ 

(4 marks)

(a)	<ul> <li>Sketch a profile for the atmosphere up to 100km illustrating changes in temperature and providing names for each of the regions.</li> <li>What are the <b>major gases</b> (include % composition) in the atmosphere at sea level? (3 marks)</li> </ul>
(b)	<ul> <li>Illustrate using chemical equations the formation and destruction of ozone in the ozone layer.</li> <li>How is Freon-12 involved in the catalytic destruction of ozone? (2 marks)</li> </ul>
(c)	<ul> <li>Sketch the biogeochemical cycle of carbon. On your sketch:</li> <li>Indicate the main reservoirs, main chemicals, direction of fluxes.</li> <li>Why does fossil fuel combustion impact on this cycle. (3 marks)</li> </ul>

# **Question 8**

(a)	Calculate the <b>pH</b> of the following aqueous solution:		
	• 0.13 mol dm <sup>-3</sup> propionic acid	pK <sub>a</sub> [propionic acid]	= 4.90
		(3 n	narks)
(b)	Acid rain is a classic example of regional scale pollution.		

- What is acid rain as opposed to normal rain?
  - - Provide chemical equations to illustrate the formation of acid rain.

(2 marks)

#### (c) Water treatment (drinking water supply) in a large city such as Melbourne and a small city such as Cairns share some common steps.

- Sketch the typical features of a water treatment plant that you would • expect to see in both cities.
- List two water quality parameters that are routinely measured in a • drinking water to establish that it is fit for consumption?

(3 marks)

# **EQUATION LIST**

# TABLE 1

$CaCO_3 + 2H^+$	$\rightarrow Ca^{2+} + CO_2 + H_2O$
$CaCO_3 + H_2SO_4 + H_2O$	$\rightarrow$ CaSO <sub>4</sub> .2H <sub>2</sub> O + CO <sub>2</sub>
$4\text{FeS}_2 + 15\text{O}_2 + 14\text{H}_2\text{O}$	$\rightarrow$ 4Fe(OH) <sub>3</sub> + 8H <sub>2</sub> SO <sub>4</sub>
$2SO_2 + 2H_2O + O_2$	$\rightarrow 2H_2SO_4$ (Mn cat.)

# TABLE 2

Physical Quantity	Name of Unit	Symbol for Unit
Length	metre	m
Mass	kilogramme	kg
Time	second	S
Electric Current	ampere	a
Thermodynamic Temperature	kelvin	Κ
Amount of Substance	mole	mol
Volume	cubic metre	m <sup>3</sup>
Frequency	hertz	Hz
Velocity	metre per second	ms <sup>-1</sup>
Acceleration	metre per second squared	ms <sup>-2</sup>
Density	kilogramme per cubic metre	kg m <sup>-3</sup>
Molar Mass	kilogramme per mole	kg mol <sup>-1</sup>
Concentration	mole per cubic metre	mol m <sup>-3</sup>
Molality	mole per kilogramme	mol kg <sup>-1</sup>
Force	newton	Ν
Pressure	pascal	Ра
Energy	joule	J
Electric Charge	coulomb	С
Electron Potential Difference	volt	V

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																			18/VIII	
		1	2	_					1 H 1.008					13/111	14/IV	15/V	16/VI	17/VII	2 He 4.003	
		3	4							_				5	6	7	8	9	10	
	2	Li	Be											В	С	Ν	0	F	Ne	
		6.941	9.012											10.81	12.01	14.01	16.00	19.00	20.18	
		11	12											13	14	15	16	17	18	
	3	Na	Mg											AI	Si	Р	S	CI	Ar	
		22.99	24.30	3	4	5	6	7	8	9	10	11	12	26.98	28.09	30.97	32.07	35.45	39.95	
		19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	
σ	4	K	Ca	Sc	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn	Ga	Ge	As	Se	Br	Kr	
0		39.10	40.08	44.96	47.87	50.94	52.00	54.94	55.85	58.93	58.69	63.55	65.39	69.72	72.61	74.92	78.96	79.90	83.80	
1		37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	
Φ	5	Rb	Sr	Y	Zr	Nb	Мо	Тс	Ru	Rh	Pd	Ag	Cd	In	Sn	Sb	Te		Xe	
Δ		85.47	87.62	88.91	91.22	92.91	95.94	98.91	101.1	102.9	106.4	107.9	112.4	114.8	118.7	121.8	127.6	126.9	131.3	
		55	56		72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	
	6	Cs	Ba	La-	Hf	Та	W	Re	Os	lr	Pt	Au	Hg	TI	Pb	Bi	Po	At	Rn	
		132.9	137.3	LU	178.5	180.9	183.8	186.2	190.2	192.2	195.1	197.0	200.6	204.4	207.2	209.0	210.0	210.0	222.0	
		87	88	<b>A a</b>	104	105	106	107	108	109										
	7	Fr	Ra	AC-	Unq	Unp	Unh	Uns	Uno	Une										
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Lanthanides 57 58 59							59	60	61	62	63	64	65	66	67	68	69	70	71	
, ,					١.	La	Ce	Pr	Nd	Pm	Sm	Eu	Gd	Tb	Dy	Ho	Er	Tm	Yb	Lu
$\backslash$				$\backslash$	138.9	140.1	140.9	146.2	144.9	150.4	152.0	157.2	158.9	162.5	164.9	167.3	168.9	173.0	175.0	
3 /					89	90	91	92	93	94	95	96	97	98	99	100	101	102	103	
Actinide					Ac	Th	Ра	U	Np	Pu	Am	Cm	Bk	Cf	Es	Fm	Md	No	Lr	
			\	227.0	232.0	231.0	238.0	237.0	239.1	241.1	244.1	249.1	252.1	252.1	257.1	258.1	259.1	262.1		
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