SCIENCE TEACHERS ASSOCIATION VICTORIA 2023

TRIAL EXAMINATION

QUESTION AND ANSWER BOOK

Total writing time:
1 hour 30 minutes

CHEMISTRY
UNIT 3

Student name	

Student ID									Letter	

Structure of book

Section	Number of questions	Number of marks
A	20	20
B	10	73
	Total	**93**

- Students are permitted to bring into the examination room: pens, pencils, highlighters, erasers, sharpeners, rulers and an approved scientific calculator.
- Students are NOT permitted to bring into the examination room: blank sheets of paper and/or white out liquid/tape.

Materials supplied

- Question and answer book of 15 pages with a detachable answer sheet for multiple-choice questions inside the front cover.

Instructions

- Detach the answer sheet for multiple-choice questions during reading time.
- Write your name and student ID in the space provide above on this page and on the answer sheet for multiple-choice questions.
- All written responses should be in English.

At the end of the examination

- Place the answer sheet for multiple-choice questions inside the front cover of this book.

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STAV House, 5 Munro Street,
Coburg VIC 3058 Australia
PHONE: 61 + 3 9385 3999
EMAIL: admin@stav.vic.edu.au
ABN: 59 004 145 329

STAV
2023

CHEMISTRY
Unit 3 Trial Examination
MULTIPLE CHOICE ANSWER SHEET

STUDENT NAME:	

INSTRUCTIONS: **USE PENCIL ONLY**

- Write your name in the space provided above.
- Use a **PENCIL** for **ALL** entries.
- If you make a mistake, **ERASE** it – **DO NOT** cross it out.
- Marks will **NOT** be deducted for incorrect answers.
- **NO MARK** will be given if more than **ONE** answer is completed for any question.
- Mark your answer by **SHADING** the letter of your choice.

	ONE ANSWER PER LINE					ONE ANSWER PER LINE				
1	A	B	C	D	11	A	B	C	D	
2	A	B	C	D	12	A	B	C	D	
3	A	B	C	D	13	A	B	C	D	
4	A	B	C	D	14	A	B	C	D	
5	A	B	C	D	15	A	B	C	D	
6	A	B	C	D	16	A	B	C	D	
7	A	B	C	D	17	A	B	C	D	
8	A	B	C	D	18	A	B	C	D	
9	A	B	C	D	19	A	B	C	D	
10	A	B	C	D	20	A	B	C	D	

SECTION A – Multiple-choice questions

Instructions for Section A
Answer all questions in pencil on the answer sheet provided for multiple-choice questions. Choose the response that is **correct** or that **best answers** the question. A correct answer scores 1, an incorrect answer scores 0. Marks will **not** be deducted for incorrect answers. No mark will be given if more than one answer is completed for any question.

Question 1

Which one of the following best describes a renewable energy source?

A. A renewable energy source can be produced at a slower rate than the rate at which it is used.

B. A renewable energy source can be produced at a faster rate than the rate at which it is used.

C. A renewable energy source can be produced at the same rate at which it is used.

D. The rate at which a renewable energy source can be produced is not related to the rate at which it is used.

The next two questions refer to the following information regarding the complete combustion of ethyne (acetylene):

$$2C_2H_2(g) + 5O_2(g) \rightarrow 4CO_2(g) + 2H_2O(l)$$

Question 2

The combustion of 0.52 g of ethyne will

A. absorb 26 J of energy.

B. release 26 J of energy.

C. absorb 26 kJ of energy.

D. release 26 kJ of energy.

Question 3

The carbon dioxide contribution from the combustion of this mass of ethyne is closest to

A. 34 g MJ^{-1}

B. 68 g MJ^{-1}

C. 136 g MJ^{-1}

D. 268 g MJ^{-1}

Question 4

Burning 9.00 g of a fuel raises the temperature of 150 g of water by 60.0°C. The heat of combustion, in kJ g^{-1} of the fuel is closest to

A. 0.0150

B. 0.114

C. 4.18

D. 4.80

Question 5

Which of the following examples is the most efficient in energy conversion?

A. Chemical energy in coal being converted into electrical energy in power plants.

B. Light energy being converted into electrical energy in solar panels.

C. Light energy from the sun being converted into chemical energy in plants.

D. Chemical energy in a lithium battery being converted into electrical energy.

Question 6

In an endothermic reaction

A. bonds are stronger in the products and energy content is higher in the products.

B. bonds are weaker in the products and energy content is higher in the products.

C. bonds are stronger in the products and energy content is lower in the products.

D. bonds are weaker in the products and energy content is lower in the products.

Question 7

Which one of the following conversions could be achieved using an oxidising agent?

A. $Cr_2O_7^{2-}(aq) \rightarrow Cr^{3+}(aq)$

B. $SO_3(g) \rightarrow SO_4^{2-}(aq)$

C. $Cl^-(aq) \rightarrow ClO^-(aq)$

D. $H^+(aq) \rightarrow H_2(g)$

Question 8

A step in the production of sulfuric acid involves the conversion of sulfur dioxide to sulfur trioxide according to the equation:

$$2SO_2(g) + O_2(g) \rightleftharpoons 2SO_3(g) \qquad \Delta H = -197 \text{ kJ mol}^{-1}$$

The pressure in the converter where this reaction takes place is maintained at approximately 1 atmosphere. A higher pressure would result in

A. a higher equilibrium yield and a faster rate of reaction.

B. a higher equilibrium yield and a slower rate of reaction.

C. a lower equilibrium yield and a faster rate of reaction.

D. a lower equilibrium yield and a slower rate of reaction.

The next two questions refer to the following information.

A mixture of ethene gas and hydrogen gas was allowed to react in a sealed, 500 mL flask. The equilibrium that resulted may be represented as:

$$C_2H_4(g) + H_2(g) \rightleftharpoons C_2H_6(g)$$

At equilibrium, there was found to be 1.25×10^{-1} mol of $C_2H_6(g)$, 7.50×10^{-2} mol of $C_2H_4(g)$ and 8.35×10^{-2} mol of $H_2(g)$ present in the flask.

Question 9

The equilibrium constant for this reaction under these conditions is

A. 0.0501

B. 0.100

C. 9.98

D. 20.0

Question 10

Which one of the following would result in a change in the value of the equilibrium constant for this reaction?

A. increasing the concentration of $C_2H_4(g)$

B. adding a catalyst

C. increasing the volume in the flask

D. decreasing the temperature of the reaction flask

Question 11

When 0.010 mol of iodine is added to 1.0 L of 0.20 M aqueous potassium iodide, 99% is converted to the triiodide ion according to:

$$I_2(aq) + I^-(aq) \rightleftharpoons I_3^-(aq)$$

What is the approximate value of the equilibrium constant?

A. $5.2 \times 10^2\ M^{-1}$

B. $1.4 \times 10^3\ M^{-1}$

C. $2.8\ M^{-1}$

D. $2.8 \times 10^{-3}\ M^{-1}$

Question 12

The equilibrium constant for the dissociation of hydrogen iodide into its elements, according to the equation below, at 900 K is 0.040.

$$2HI(g) \rightleftharpoons H_2(g) + I_2(g)$$

If the equilibrium concentration of hydrogen iodide is 0.20 M, what is the equilibrium concentration of iodine?

A. 0.30 M

B. 0.040 M

C. 0.0080 M

D. 0.0016 M

Question 13

The K_c for the reaction $2N_2O(g) \rightleftharpoons 2N_2(g) + O_2(g)$ is 7.3×10^{34} M

What is the numerical value of K_c for the following reaction at the same temperature?

$$N_2(g) + \tfrac{1}{2}O_2(g) \rightleftharpoons N_2O(g)$$

A. 7.3×10^{34}

B. $\frac{1}{\sqrt{7.3 \times 10^{34}}}$

C. $\frac{2}{\sqrt{7.3 \times 10^{34}}}$

D. $\frac{1}{2 \times 7.3 \times 10^{34}}$

Question 14

In which one of the following would you expect a reaction to occur?

A. copper placed in aqueous zinc chloride.

B. zinc placed in aqueous silver nitrate.

C. iron placed in aqueous magnesium sulfate.

D. magnesium placed in aqueous sodium chloride.

Question 15

Which one of the following is the cell potential under standard conditions for the reaction:

$$Ni^{2+}(aq) + Pb(s) \rightarrow Ni(s) + Pb^{2+}(aq)$$

A. +0.12 V

B. −0.12 V

C. +0.38 V

D. −0.38 V

Question 16

Which one of the following is the correct half-equation for the iodate ion in acidic solution changing to iodine?

A. $IO_3^- + 6H^+ \rightarrow I + 3H_2O + 5e^-$

B. $IO_3^- + 6H^+ + 5e^- \rightarrow I + 3H_2O$

C. $IO_3^- + 6H^+ + 5e^- \rightarrow I_2 + 3H_2O$

D. $2IO_3^- + 12H^+ + 10e^- \rightarrow I_2 + 6H_2O$

Question 17

A number of possible oxidising agents are suggested to oxidise bromide ions to bromine.
Which one of the following is the most likely to succeed?

A. iodate(V) ions $2IO_3^- + 12H^+ + 10e^- \rightleftharpoons I_2 + 6H_2O \quad E^o = +1.19$ V

B. copper(II) ions

C. vanadium(III) ions $V^{3+} + e^- \rightleftharpoons V^{2+} \quad E^o = -0.26$ V

D. hydrogen gas

Question 18

In an oxygen / methanol fuel cell

A. the oxidant is methanol and it is oxidised at the anode.

B. the oxidant is methanol and it is reduced at the cathode.

C. the reductant is methanol and it is oxidised at the anode.

D. the reductant is methanol and it is reduced at the cathode.

Question 19

Which one of the following salts would give the same products irrespective of whether the molten salt or the aqueous solution is electrolysed?

A. magnesium bromide.

B. copper(II) sulfate.

C. magnesium sulfate.

D. copper(II) bromide.

Question 20

An electric current is passed through two electrolysis cells that are connected in series. In the first cell, copper is deposited on the cathode from aqueous copper(II) sulfate. In the second cell, silver is deposited on the cathode from aqueous silver nitrate. After a certain length of time, the mass of copper increased by 1.0 g. The increase in mass, in g, of the silver electrode will be closest to

A. 0.29

B. 0.85

C. 1.2

D. 3.4

END OF SECTION A

SECTION B – Short answer questions (73 marks)

Instructions for Section B

Answer **all** questions in the spaces provided.

To obtain full marks for your responses you should

- give simplified answers with an appropriate number of significant figures for all numerical questions; unsimplified answers will not be given full marks.
- show all working in your answers to numerical questions. No credit will be given for an incorrect answer unless it is accompanied by details of the working.
- make sure chemical equations are balanced and that the formulas for individual substances include an indication of state; for example, $H_2(g)$; NaCl(s)

Question 1

When Cl_2 is bubbled into cold, dilute potassium hydroxide, the following equilibrium is established:

$$Cl_2(aq) + 2OH^-(aq) \rightleftharpoons Cl^-(aq) + ClO^-(aq) + H_2O(l)$$

a. Use oxidation numbers to clearly explain why this is a redox reaction.

_____

_____

_____

2 marks

b. Identify the reducing agent in the **reverse** direction of the equilibrium.
Explain your answer.

_____

_____

_____

2 marks

c. If more chlorine was added to the equilibrium mixture, what would happen to the pH of the mixture? Explain your answer.

_____

_____

_____

_____

3 marks

Total 7 marks

Question 2

Butan-1-ol burns according to the following thermochemical equation:

$$CH_3CH_2CH_2CH_2OH(l) + 6O_2(g) \rightarrow 4CO_2(g) + 5H_2O(l) \qquad \Delta H = -2670 \text{ kJ mol}^{-1}$$

20.0 mL of butan-1-ol is burned. The density of butan-1-ol is 0.81 g mL^{-1}.

a. Calculate the mass of water produced.

_____

_____

_____

3 marks

b. Calculate the volume of carbon dioxide produced at SLC.

_____

_____

_____

3 marks

c. Calculate the volume of carbon dioxide produced at 100°C and 1.60 atm.

_____

_____

_____

2 marks

d. If the butan-1-ol is used to produce 100 mL of carbon dioxide at SLC, calculate the mass of butan-1-ol needed.

_____

_____

_____

3 marks

e. What mass of ethanol would be needed to produce the same energy as that produced from the combustion of 1.00 mol of butan-1-ol.

_____

_____

_____

2 marks

Total 13 marks

Question 3

A camping stove, burning butane, was used to heat 500 g of water, initially at 20.0°C to its boiling point. Heating the same amount of water from 20.0°C to boiling point with an electrical heater was found to require 168 kJ of electrical energy.

a. If the pot weighed 100 g and it was made out of aluminium, how much energy was required to heat the pot given the specific heat capacity of aluminium is 875 J kg^{-1} K^{-1}.

_____

_____

_____

2 marks

b. What is the total energy required to heat the pot and the water using the stove?

_____

_____

_____

2 marks

c. When the water started to boil, the stove weighed 7.25 g less than it had initially. Calculate the amount of butane (C_4H_{10}), in mol, used to heat the pot and the water.

_____

_____

1 mark

d. Use the data to determine the enthalpy of reaction, in kJ mol^{-1}, of butane with excess oxygen. All working must be shown.

_____

_____

_____

2 marks

e. The accepted value is 2880 kJ mol^{-1}. Explain why this value and your answer to part **d.** are different.

_____

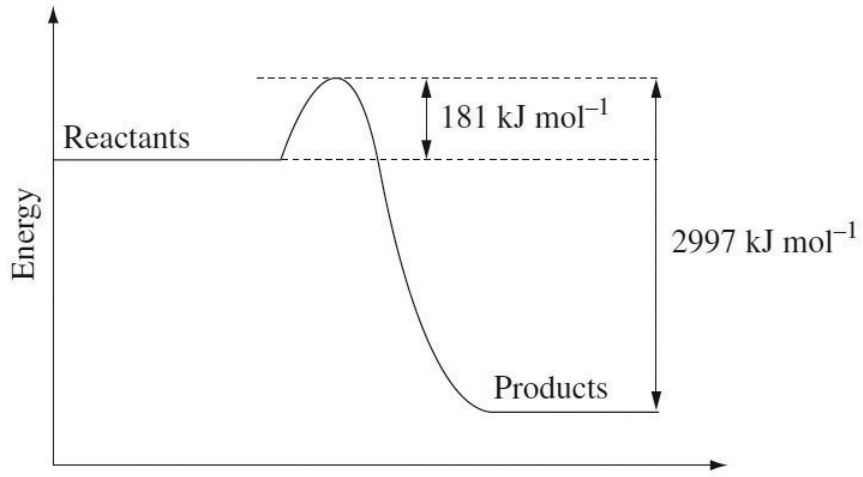
_____

1 mark

Total 8 marks

Question 4

The following diagram gives the energy profile diagram for the complete combustion of glucose powder, $C_6H_{12}O_6$.



a. Write a balanced thermochemical equation for the complete combustion of glucose **based on the data provided in this question.**

_____

_____

_____

4 marks

b. Calculate the energy released per gram of glucose.

_____

_____

1 mark

Total 5 marks

Question 5

Consider the reaction: $2H_2(g) + O_2(g) \rightarrow 2H_2O(l)$ which can be utilised in a fuel cell.

For this reaction, at 25°C, $\Delta H = -576$ kJ mol^{-1}

a. State whether this reaction is exothermic or endothermic. Briefly explain why.

_____

_____

1 mark

b. Which has the greater enthalpy, the products or the reactants? Briefly explain why.

_____

_____

2 marks

c. What is the value of ΔH for the following reaction at the same temperature?

$$H_2O(l) \rightarrow H_2(g) + \tfrac{1}{2}O_2(g)$$

_____

1 mark

d. Given that, at 25°C: $H_2O(l) \rightarrow H_2O(g)$ $\Delta H = +44$ kJ mol^{-1}

calculate the value of ΔH for the reaction: $2H_2(g) + O_2(g) \rightarrow 2H_2O(g)$

_____

_____

_____

_____

_____

3 marks

e. Explain why the nature of the electrodes is crucial in a hydrogen / oxygen fuel cell.

_____

_____

_____

_____

2 marks

Total 9 marks

Question 6

Consider the gaseous equilibrium: $CO(g) + Cl_2(g) \rightleftharpoons COCl_2(g)$

a. Write the expression for the the equilibrium constant, K_c.

_____

_____

1 mark

b. The equilibrium concentrations of the various species at a particular temperature are:

$[CO] = 0.800$ M $\quad [Cl_2] = 0.600$ M $\quad [COCl_2] = 0.200$ M

Calculate the value of the equilibrium constant, K_c, giving the appropriate unit.

_____

_____

2 marks

c. **i.** If the pressure of the system is suddenly increased by halving the volume at constant temperature, how will this affect the amount of $COCl_2$ produced? Explain your response.

_____

_____

_____

2 marks

ii. Calculate the concentration fraction at the instant the volume is decreased. Is the system still at equilibrium? If not, in which direction will the reaction proceed? Explain how you reached your answer.

_____

_____

_____

_____

_____

4 marks

d. Is your answer in **cii.** consistent with Le Chatelier's principle? Explain your answer.

_____

_____

1 mark

Total 10 marks

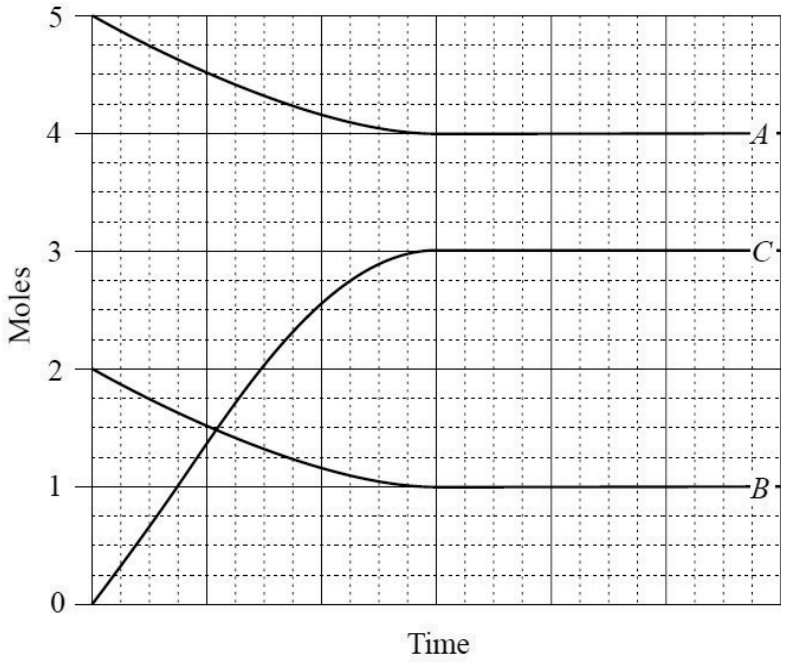
Question 7

Two substances *A* and *B* react according to the equation:

$$A + B \rightleftharpoons 3C$$

5.0 moles of *A* and 2.0 moles of *B* are mixed in a 2.00 L closed container. The reaction is allowed to come to equilibrium at temperature *T*.

The graph below shows the variation in moles of *A*, *B* and *C* over time.



Calculate the value of the equilibrium constant, K_c, including units for the reaction at temperature *T*. Show all of your working.

Total 5 marks

Question 8

The standard electrode potentials of two metal / metal ion half-cells are shown below.

$$X^{2+} + 2e^- \rightarrow X \qquad E^o = +0.45 \text{ V}$$

$$Y^{2+} + 2e^- \rightarrow Y \qquad E^o = +0.87 \text{ V}$$

a. When a galvanic cell is constructed using these two half-cells, which metal, X or Y, will form the positive electrode? Explain your reasoning.

_____

_____

_____

_____

_____

3 marks

b. If metal Y were used as a protective coating on metal X, would it continue to protect metal X if the coating were scratched so as to expose bare metal X? Explain your response.

_____

_____

_____

_____

_____

2 marks

Total 5 marks

Question 9

A block of nickel and a block of copper are joined together and then the combined block is placed in a solution of 1.0 M HCl(aq) at 25°C. It was observed that bubbles of gas are only evolved from the surface of the copper. However, if the two blocks are separated and placed in the same acid at 25°C, the bubbles only appear on the nickel surface. Explain these observations and include half-equations to support your explanation.

_____

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_____

Total 5 marks

Question 10

When a current of 7.50 A was passed through a concentrated solution of lithium chloride using platinum electrodes, 2.1 L of chlorine gas was produced under SLC conditions. How long, in minutes, did the electrolysis take?

_____

_____

_____

_____

_____

_____

_____

_____

Total 6 marks

END OF TRIAL EXAMINATION