

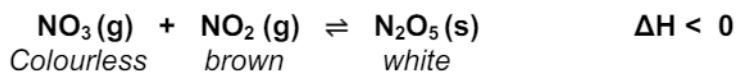
Section One: Multiple Choice**25% (25 marks)**

This section contains **25** questions. Answer **all** questions on the Multiple-choice Answer Sheet provided. For each question shade the box to indicate your answer. Use blue or black pen to shade the boxes. Do not use erasable or gel pens. If you make a mistake, place a cross through that square, then shade your new answer. Do not erase or use correction fluid/tape. Marks will not be deducted for incorrect answers. No marks will be given if more than one answer is given for any question.

Suggested working time for this section is 50 minutes.

Questions 1 and 2 relate to the following equilibrium system.

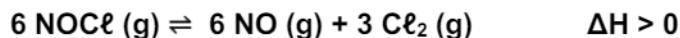
Samples of $\text{NO}_3(\text{g})$ and $\text{NO}_2(\text{g})$ were injected into an empty flask and equilibrium was established according to the following equation.



1. While the system was establishing equilibrium, which of the following would be observed?
 - (a) The mass of the system increases.
 - (b) The mass of the white solid does not change.
 - (c) The temperature in the flask decreases.
 - (d) The pressure of the system decreases.

2. After equilibrium is established, which of the following changes to the system would cause the rate of the forward reaction to increase?
 - (i) Adding additional $\text{NO}_3(\text{g})$.
 - (ii) Increasing the temperature.
 - (iii) Decreasing the total volume of the system.
 - (iv) Removing the $\text{N}_2\text{O}_5(\text{s})$ from the system as it forms.
 - (a) (i) and (iii) only.
 - (b) (i) and (iv) only.
 - (c) (i), (ii) and (iii) only.
 - (d) All of them.

3. Consider the following equilibrium system.



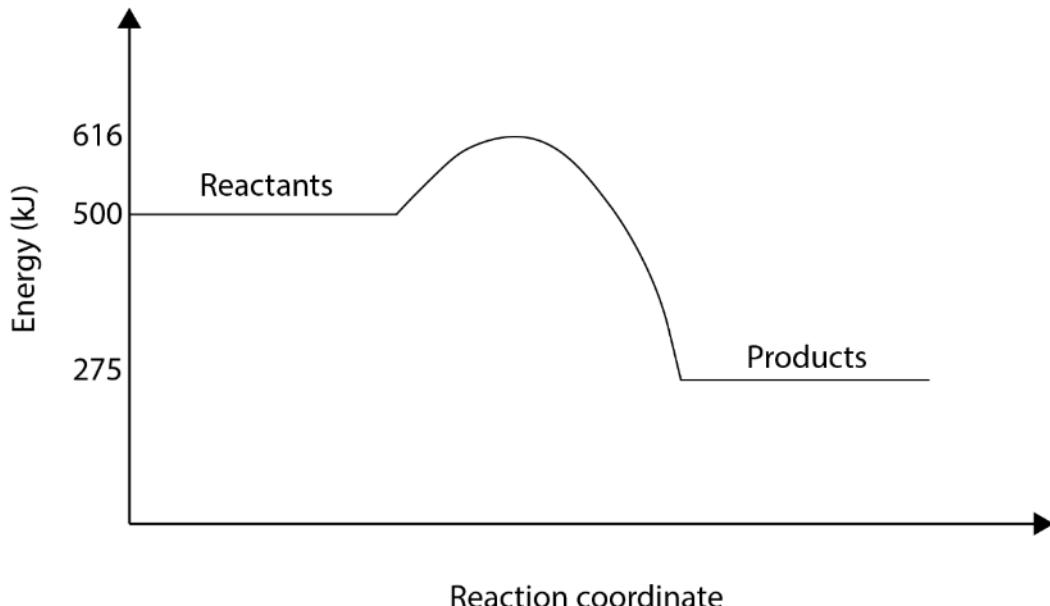
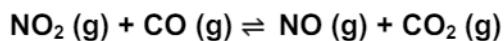
A chemist wanted to:

- shift the equilibrium position to the left
- decrease the rate of the reverse reaction
- leave the K value unchanged

Which change should they impose on the system to satisfy all three criteria once equilibrium is re-established?

- (a) Remove some NOCl (g) from the system.
- (b) Decrease the volume of the system.
- (c) Decrease the temperature of the system.
- (d) Add some NO (g) to the system.

4. Below is an energy profile diagram that represents the following reaction:



Adding a catalyst to the system halves the activation energy of the forward reaction. Which of the following statements is **true**?

- (a) The activation energy of the catalysed reverse reaction is 341 kJ.
- (b) ΔH for the forward and reverse reactions is the same.
- (c) The rate of the reverse reaction would increase by more than the forward when the temperature is increased.
- (d) In the forward reaction, there are more bonds formed than bonds broken.

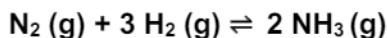
5. Substance A decomposes into B and C as indicated by the following reaction:



1.5 moles of A is placed inside a closed vessel of fixed volume and the system comes to equilibrium. At equilibrium, the amount of A present has decreased to 1.0 moles, but the total number of moles in the container has increased to 3.0 moles. What is the value of x?

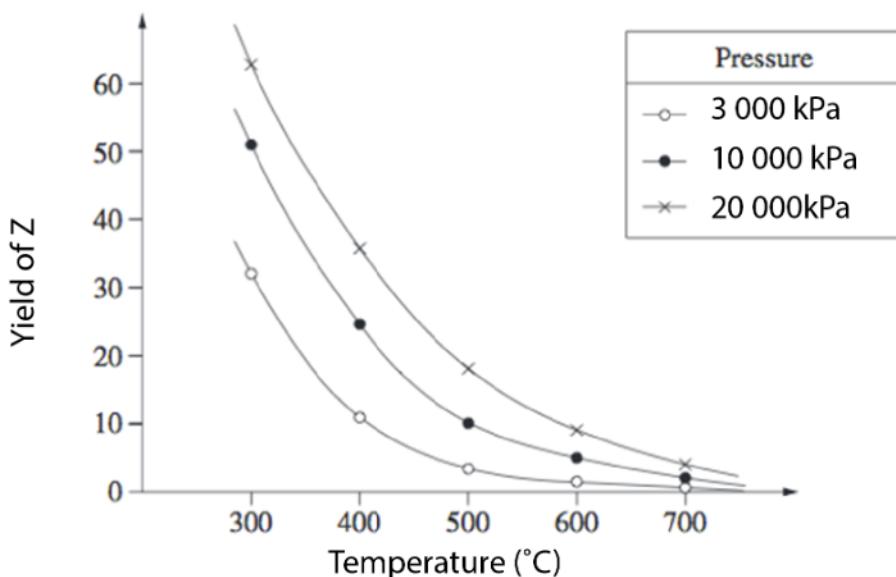
- (a) 1
- (b) 2
- (c) 3
- (d) 4

6. The Haber process, shown below, is usually conducted at a moderate temperature and a high pressure. Which of the following statements are **true**?



- (i) The forward reaction is endothermic.
 - (ii) Using a higher temperature would increase the cost of production.
 - (iii) Lowering the temperature would decrease the yield of ammonia.
 - (iv) Using a high pressure increases the rate of the reverse reaction.
-
- (a) (i), (ii) and (iv) only
 - (b) (ii) and (iv) only
 - (c) (ii), (iii) and (iv) only
 - (d) (ii) only

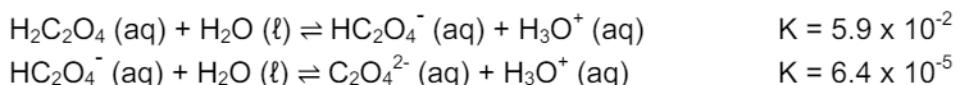
7. The graph below represents the yield of an equilibrium reaction at different temperature and pressure conditions inside a reaction vessel.



Which of the following reactions could produce the trends shown in the graph?

- (a) $X(g) + Y(g) \rightleftharpoons 3Z(g)$ $\Delta H = +100 \text{ kJ}$
- (b) $X(g) + Y(g) \rightleftharpoons 3Z(g)$ $\Delta H = -100 \text{ kJ}$
- (c) $2X(g) + Y(g) \rightleftharpoons Z(g)$ $\Delta H = +100 \text{ kJ}$
- (d) $X(g) + Y(g) \rightleftharpoons Z(g)$ $\Delta H = -100 \text{ kJ}$

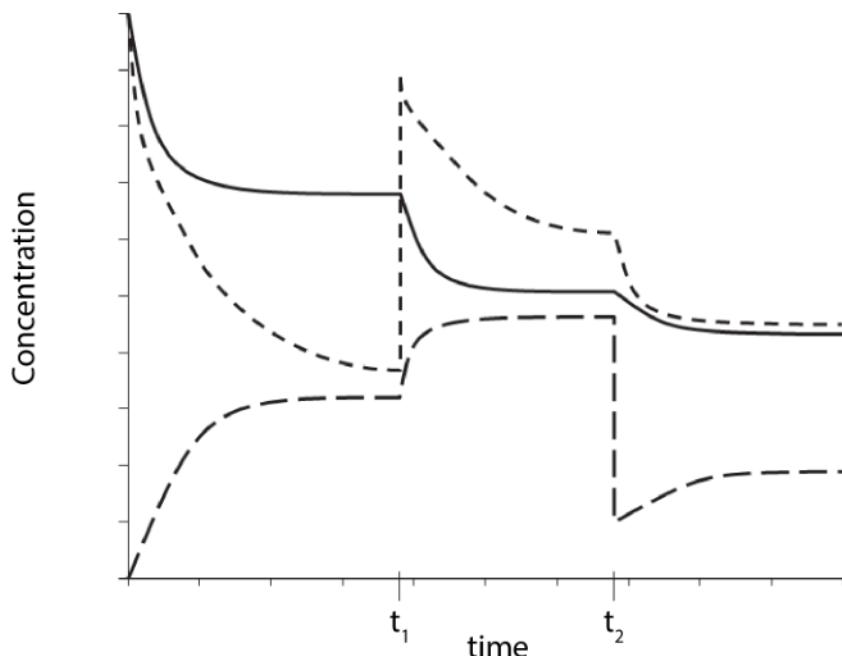
8. Oxalic acid is a weak diprotic acid that hydrolyses according to the following reactions:



Which of the following correctly lists the species present in order of decreasing concentration in a 1 mol L^{-1} solution of $\text{H}_2\text{C}_2\text{O}_4$?

- (a) $\text{H}_2\text{C}_2\text{O}_4 > \text{H}_3\text{O}^+ > \text{HC}_2\text{O}_4^- > \text{C}_2\text{O}_4^{2-} > \text{OH}^-$
- (b) $\text{C}_2\text{O}_4^{2-} > \text{HC}_2\text{O}_4^- > \text{H}_2\text{C}_2\text{O}_4 > \text{H}_3\text{O}^+ > \text{OH}^-$
- (c) $\text{H}_2\text{C}_2\text{O}_4 > \text{HC}_2\text{O}_4^- > \text{H}_3\text{O}^+ > \text{C}_2\text{O}_4^{2-} > \text{OH}^-$
- (d) $\text{OH}^- > \text{C}_2\text{O}_4^{2-} > \text{HC}_2\text{O}_4^- > \text{H}_3\text{O}^+ > \text{H}_2\text{C}_2\text{O}_4$

9. The unlabelled graph below shows the concentrations of the reactants and products over time for the reaction shown below.



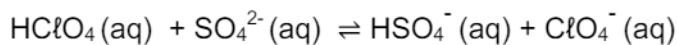
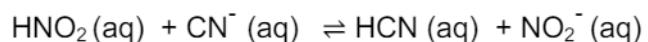
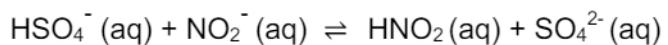
What option below represents the changes that took place at t_1 and t_2 ?

	t_1	t_2
(a)	A added	B removed
(b)	B added	A removed
(c)	A added	C removed
(d)	B added	C removed

10. Which of the following is not a conjugate acid/base pair?

- (a) HOCl and OCl^-
- (b) $\text{Cu}(\text{H}_2\text{O})_6^{2+}$ and $\text{Cu}(\text{H}_2\text{O})_5\text{OH}^+$
- (c) H_2O_2 and HO_2^-
- (d) $\text{CH}_3\text{CH}_2\text{COOH}$ and $\text{CH}_2\text{CHCOO}^-$

11. The following three reactions all have K values > 1.



Which is the strongest base?

- (a) CN^-
- (b) SO_4^{2-}
- (c) ClO_4^-
- (d) NO_2^-

12. Given that HF is a stronger acid than CH_3COOH , which of the following 1 mol L^{-1} solutions would have the highest pH?

- (a) HF (aq)
- (b) NaF (aq)
- (c) CH_3COOH (aq)
- (d) NaCH_3COO (aq)

13. Which of the following mixtures would make the buffer solution with the highest capacity?

- (a) 100 mL of 1 mol L^{-1} HNO_3 and 50 mL of 1 mol L^{-1} NaOH
- (b) 100 mL of 2 mol L^{-1} CH_3COOH and 100 mL of 1 mol L^{-1} NaOH
- (c) 100 mL of 2 mol L^{-1} CH_3COOH and 50 mL of 2 mol L^{-1} HCl
- (d) 100 mL of 2 mol L^{-1} NH_4Cl and 50 mL of 2 mol L^{-1} NaOH

14. Universal Indicator undergoes the following colour changes with pH:

pH	0-2	3-4	5	6-9	10-12	13-14
colour	red	orange	yellow	green	blue	purple

Which of the following describes the colour changes that would take place when 10 mL of 1 molL^{-1} NH_3 (aq) is added to 10 mL of 1 molL^{-1} HCl solution. Universal Indicator is initially added to the HCl solution.

- (a) red \rightarrow orange \rightarrow yellow \rightarrow green \rightarrow blue
- (b) yellow \rightarrow green \rightarrow blue
- (c) red \rightarrow orange \rightarrow yellow
- (d) orange \rightarrow yellow \rightarrow green

15. Which solution is most likely to have a pH of -0.30 at 25°C ?

- (a) 2 molL^{-1} CH_3COOH
- (b) 1.8 molL^{-1} HCl
- (c) 1.0 molL^{-1} H_2SO_4
- (d) none of the above

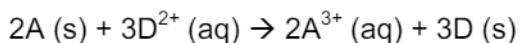
16. In which of the following does the oxidation number of the named element increase from left to right?

- | | | | | | |
|-----|-----------|-------------------------|----------------|-----------------------------|-----------------------------------|
| (a) | carbon: | C | CN^- | $\text{C}_2\text{O}_4^{2-}$ | HCO_3^- |
| (b) | nitrogen: | NO^{2+} | NO_2 | NO_3^- | N^{3-} |
| (c) | sulfur: | SO_2 | S_8 | H_2S | $\text{Na}_2\text{S}_2\text{O}_3$ |
| (d) | chromium: | Cr_2O_3 | CrO_3 | H_2CrO_4 | $\text{K}_2\text{Cr}_2\text{O}_7$ |

17. Listed below are two reduction half equations:



What is the standard reduction potential of the following reaction?



- (a) -0.17 V
- (b) +0.17 V
- (c) +1.03 V
- (d) -1.03 V

18. Consider the following unbalanced equation:

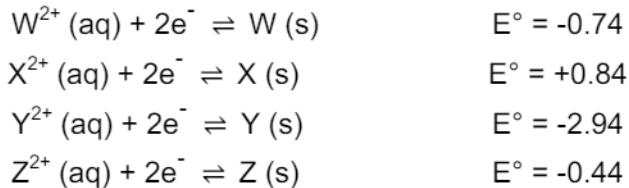


What are the correct values for the coefficients a and b?

	a	b
(a)	3	1
(b)	5	1
(c)	1	3
(d)	1	5

19. Engineers need to carry out maintenance on a steel pipeline to carry water in the Kimberley. They decide to place metal blocks at regular intervals along the steel pipeline to reduce the amount of rusting.

The different metals they can choose from are unknown metals, W, X, Y and Z. Using the standard reduction potentials given below and your data sheet, decide which is the best metal the engineers should choose for the blocks.



- (a) W
- (b) X
- (c) Y
- (d) Z

Questions 20 and 21 relate to the following information.

A group of three students were conducting an experiment to investigate the temperature and volume changes associated with dissolving a series of compounds in water. 10.00 mL of ethanol was dissolved in 100 mL of distilled water. 10.00 g of ammonium chloride was dissolved in a second 100 mL volume of distilled water. The change in volume and temperature was recorded. The experiment was repeated. The results are shown below:

Substance being dissolved	Initial temperature (°C)	Final temperature (°C)	Initial volume (mL)	Final volume (mL)
Ethanol (CH ₃ CH ₂ OH (l))	22	28	100.0	107.2
	23	29	100.0	106.9
Ammonium chloride (NH ₄ Cl (s))	21	15	100.0	100.3
	20	15	100.0	99.7

20. Which of the following statements is **true**?

- (a) Using a more sensitive thermometer would increase the reliability of the data.
- (b) Conducting additional repeats would decrease the random error in the data.
- (c) Conducting additional repeats would make each measurement more accurate.
- (d) Using a more sensitive thermometer would decrease the systematic error present.

21. Based on the above data, which of the following conclusions would be the most appropriate to make.

- (a) The volume always increases when two substances are dissolved in each other.
- (b) When ethanol and water are mixed, there is a reduction in the total combined volume.
- (c) The volume of water does not change when ammonium chloride is dissolved in it.
- (d) If two substances are mixed and it is exothermic, then the volume will decrease.

22. Consider the following half-cells which are set up under standard conditions.

Half-cell	Electrode	Electrolyte
I	Metal A	A^{2+} (aq)
II	Platinum	B^{2+} (aq) and B^{3+} (aq)
III	Metal B	C^+ (aq)

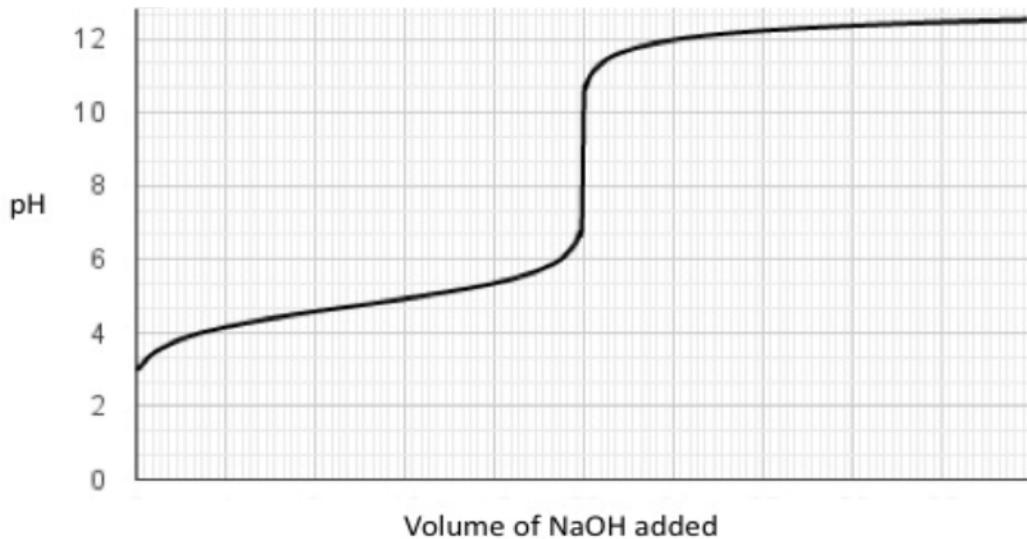
When a galvanic cell is constructed from half-cell I and II, the electrode in half-cell II is negative.

When a galvanic cell is constructed from half-cell II and half-cell III, the electrons flow toward half-cell II.

The strongest oxidant is:

- (a) A^{2+} (aq)
- (b) B^{2+} (aq)
- (c) B^{3+} (aq)
- (d) C^+ (aq)

23. A solution of 0.1 mol L^{-1} NaOH was titrated against an acidic solution X, of unknown concentration. The following titration curve was obtained, with the equivalence point occurring after 25 mL of NaOH had been added.



Which of the following is the most likely identity of solution X?

- (a) 50.0 mL of 0.05 mol L^{-1} HCN
- (b) 25.0 mL of 0.10 mol L^{-1} HNO_3
- (c) 25.0 mL of 0.05 mol L^{-1} HCN
- (d) 25.0 mL of 0.05 mol L^{-1} H_2SO_4

24. A fuel cell currently under development for powering small electronic devices is based on the reaction of methanol and oxygen using an acidic electrolyte.

In this cell, the oxidant in the cell reaction and the half-reaction occurring at the cathode are:

	Oxidant	Cathode reaction
(a)	oxygen	$\text{CH}_3\text{OH}(\text{g}) + \text{H}_2\text{O}(\ell) \rightarrow \text{CO}_2(\text{g}) + 6\text{H}^+(\text{aq}) + 6\text{e}^-$
(b)	methanol	$\text{CH}_3\text{OH}(\text{g}) + \text{H}_2\text{O}(\ell) \rightarrow \text{CO}_2(\text{g}) + 6\text{H}^+(\text{aq}) + 6\text{e}^-$
(c)	oxygen	$\text{O}_2(\text{g}) + 4\text{H}^+(\text{aq}) + 4\text{e}^- \rightarrow 2\text{H}_2\text{O}(\ell)$
(d)	methanol	$\text{O}_2(\text{g}) + 4\text{H}^+(\text{aq}) + 4\text{e}^- \rightarrow 2\text{H}_2\text{O}(\ell)$

25. When an aqueous solution of potassium bromide is electrolysed, an orange solution forms at one electrode and a colourless gas forms at the other.

Which of the following statements are **true**?

- (a) Bromide ions are oxidised at the negative electrode.
- (b) Potassium ions flow toward the electrode at which the gas is formed.
- (c) Hydrogen gas is formed at the anode.
- (d) Oxygen gas is formed at the cathode.

End of Section One