CHEMISTRY 225 FINAL EXAMINATION SEMESTER 9804
Time allowed: 3 hours COLLEGE CHEMISTRY II

Student Number..... .....Student Name.....Section.....

SECTION A: Multiple Choice [1mark each = 40 marks] . Answer ALL questions.
Each question is followed by five suggested answers. Select the best answer and shade the letter corresponding to this answer on the answer sheet provided.

1. The reaction $NO_2 + CO \rightarrow CO_2 + NO$ is second order in NO and zero order in CO. The rate law for this process is

A $R = k[NO][CO]$
B $R = k[NO]$
C $R = k[NO]^2[CO]$
D $R = k[NO]^2$
E $R = k[CO]$

2. The energy of activation for a process can be decreased by

A increasing the temperature.
B decreasing the concentrations of the reactants.
C decreasing the total volume of the reacting mixture.
D increasing the total volume of the reacting mixture.
E using a suitable catalyst.

3. The rate law for the reaction $2H_2(g) + 2NO(g) \rightarrow 2H_2O(g) + N_2(g)$ is $R = k[H_2][NO]^2$. The rate of formation of nitrogen in a particular experiment was $0.002 Ms^{-1}$. What would be the rate of formation of nitrogen, in Ms^{-1}, if the concentration of hydrogen is halved and that of nitrogen monoxide is doubled?

A 0.002
B 0.004
C 0.008
D 0.012
E 0.016

4. The following mechanism has been proposed for a reaction.

Step a $NO_2(g) + F_2(g) \rightarrow NO_2F(g) + F(g)$ slow
Step b $NO_2(g) + F(g) \rightarrow NO_2F(g)$ fast

Which statement is NOT consistent with this proposed mechanism?

A The overall reaction is $2NO_2(g) + F_2(g) \rightarrow 2NO_2F(g)$
B F is a reaction intermediate.
C The reaction is bimolecular and second order.
D The energy of activation for step a is higher than that for step b.
E The rate law for the reaction is $R = k[NO_2]^2[F_2]$

5. The following elementary steps have been proposed for a reaction.

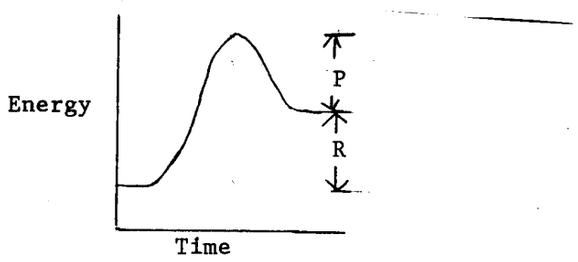
a) $2Co^{2+} + H_2O + OCl^- \rightarrow 2\,Co^{3+} + 2OH^- + Cl^-$

b) $2Co^{3+} + 2OH^- \rightarrow 2Co^{2+} + H_2O + \frac{1}{2}O_2$

The catalyst in this process is

A Co^{2+}
B Co^{3+}
C Cl^-
D OCl^-
E OH^-

6. In the energy profile diagram



A The forward reaction is exothermic.
B The activation energy for the forward process is P.
C The activation energy for the forward process is R.
D The activation energy for the forward process is P-R.
E The activation energy for the forward process is P+R.

7. In the Arrhenius equation $k = Ae^{-Ea/RT}$, $e^{-Ea/RT}$ represents

A the activation energy.
B the collision frequency.
C the fraction of molecules colliding with favourable orientation.
D the fraction of molecules with the necessary energy of activation.
E the number of molecules with the necessary energy of activation.

Questions 8 and 9 concern the following information:
The gas phase decomposition of N_2O_5 is first order with a rate constant of 1.5×10^{-4} at 55^0C. The initial concentration of N_2O_5 is 1.0M.

8. After 20s, the $\Delta [N_2O_5]$ is

A -0.0015M
B -0.003 M
C +0.0015M
D +0.003M
E +1.003M

9. After 20s, the $[N_2O_5]$ is

A 0.0015M
B 0.007M
C 0.003M
D 1.003M
E 1.007M

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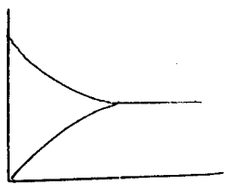
10. An inhibitor halves the rate of a reaction when its concentration is doubled. The order of the reaction with respect to this inhibitor is

A 1/2
B 1
C -1
D 2
E -2

11. The graph shown best represents



A Reaction rate versus concentration of Y for a reaction which is zero order in Y.
B Reaction rate versus concentration of Y for a reaction which is first order in Y.
C Reaction rate versus concentration of Y for a reaction which is second order in Y.
D Reaction rate versus time for a reversible process which attains equilibrium.
E Concentration of reactant versus time for a reaction which goes to completion.

12. The equilibrium constant for the reaction $X \rightleftharpoons Y$ is 7.5×10^{-6}.
Which of the following statements is TRUE?

A The equilibrium concentration of X is greater than that of Y.
B The equilibrium concentration of Y is greater than that of X.
C Adding a suitable catalyst will increase the equilibrium concentration of X.
D Adding a catalyst will increase the value of the equilibrium constant.
E Adding more X will increase the value of the equilibrium constant.

13. Which of the following **CANNOT** upset the system
$CaCO_3(s) \rightleftharpoons CaO(s) + CO_2(g)$ at equilibrium?

A Increasing the mass of calcium oxide.
B Increasing the temperature.
C Decreasing the temperature.
D Increasing the volume of the containing vessel.
E Increasing the pressure.

14. Consider the process $C_2H_6(g) \rightleftharpoons C_2H_4(g) + H_2(g)$ $\Delta H = +137kJ$
at equilibrium. The value of K_c can be increased by

A Increasing the concentration of C_2H_6.
B Adding some H_2 to the equilibrium mixture.
C Using a suitable catalyst.
D Reducing the volume of the container.
E Decreasing the temperature.

15. 0.12 mol of SO_2 and 0.10 mol of O_2 were introduced into a $2dm^3$ vessel at constant temperature. When the system reached equilibrium, 0.08mol of SO_3 was present.
The reaction is $2SO_2(g) + O_2(g) \rightleftharpoons 2SO_3(g)$.
Which set of values shows the concentration of each gas at equilibrium?

	$[SO_2]/moldm^{-3}$	$[O_2]/moldm^{-3}$	$[SO_3]/moldm^{-3}$
A	0.02	0.03	0.04
B	0.02	0.01	0.04
C	0.04	0.06	0.08
D	0.04	0.02	0.08
E	0.08	0.06	0.08

16. At a given temperature, T, some PCl_5, at an initial concentration of 1.0M, was placed in a container and allowed to reach equilibrium. It was found that the PCl_5 was 20% dissociated into PCl_3 and Cl_2 at equilibrium. K_c for the process $PCl_5(g) \rightleftharpoons PCl_3(g) + Cl_2(g)$ at temperature, T, is

A 0.20
B 0.025
C 0.05
D 3.20
E 4.0

17. When the system $NH_4CONH_2(s) \rightleftharpoons 2NH_3(g) + CO(g)$ is at equilibrium at 298K, the total pressure is 0.114atm. K_p for the system is

A 0.038
B 0.076
C 1.48×10^{-3}
D 3.51×10^{-3}
E 2.19×10^{-4}

18. For the reaction $PCl_5(g) \rightleftharpoons PCl_3(g) + Cl_2(g)$, $K_p = 1.7$ at 298K. Five systems were set up with the initial partial pressure of each gas as shown in the table. In which system would the reverse reaction occur to establish equilibrium?

	Initial partial pressure/atm		
	PCl_5	PCl_3	Cl_2
A	1	1	1
B	2	2	2
C	1	0.5	1.5
D	2	2	1
E	3	2	2

19. According to the Bronsted-Lowry definition, an acid is a substance which donates a
A hydrogen atom.
B hydrogen ion.
C hydrogen molecule.
D hydride ion.
E hydroxide ion.

20. Which does NOT constitute an acid/base conjugate pair?
A NH_4^+ / NH_2^-
B NH_3 / NH_2^-
C NH_4^+ / NH_3
D HNO_3 / NO_3^-
E HNO_2 / NO_2^-

21. The acidity constant for an acid, HA, is 2.5×10^{-6}. The pK_b of its conjugate base is
A 5.6
B 8.4
C 1.79×10^{-5}
D 1.0×10^{-14}
E 14

22. Which salt would produce a solution with the lowest pH? Assume all solutions have the same molar concentration.
A KCl
B $MgCl_2$
C $FeCl_3$
D $FeCl_2$
E $BaCl_2$

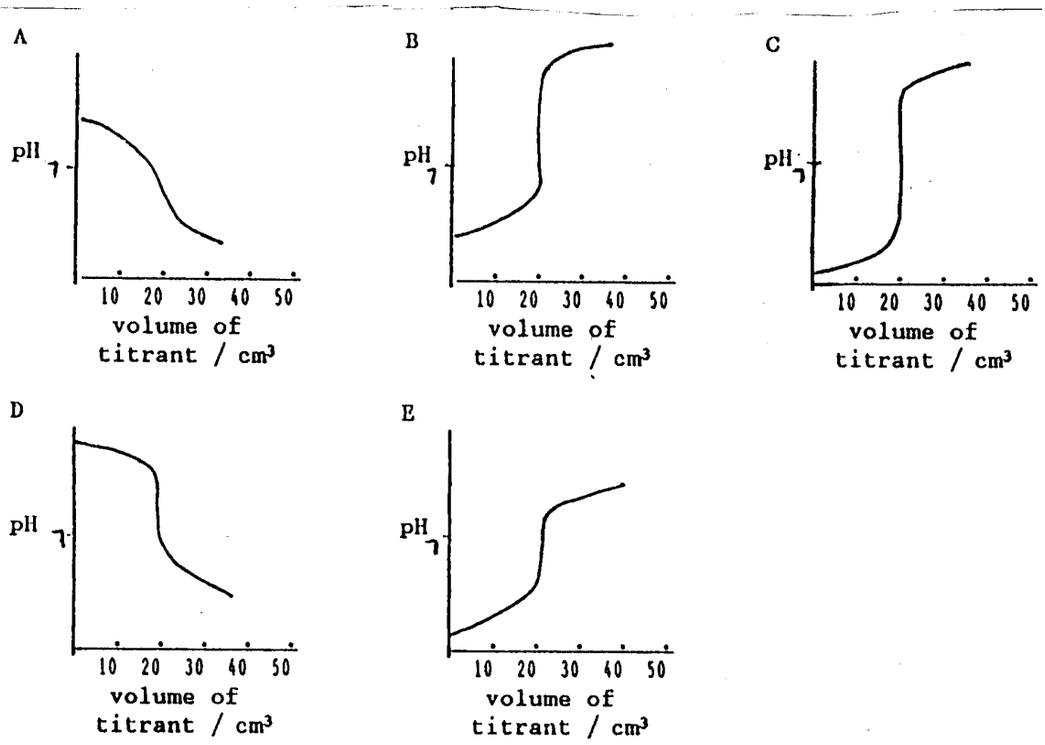
23. Which salt would produce a solution with the **highest** pH? Assume all salts have the same molar concentration.

A KCl
B $KClO$
C $KClO_2$
D $KClO_3$
E $KClO_4$

24. Which statement is true of any acid/base indicator?

A It is neither an acid nor a base.
B It always changes colour at pH 7.
C It always changes colour at a pH above 7.
D It always changes colour at a pH below 7.
E It is at the mid point of its colour change when pH = pK of the indicator.

Questions 25 to 29 . The diagrams represent titration curves for the reaction between various acids and bases.



Select ,from A to E, the curve which best represents the titration of

25. 20 $cm^3$of 0.1 M nitric acid with 0.1 M potassium hydroxide.
26. 20 cm^3 of 0.1 M potassium hydroxide with 0.1 M ethanoic acid.
27. 20 cm^3 of 0.1 M nitric acid with 0.1 M ammonia.
28. 20 cm^3 of 0.1 M ammonia with 0.1 M ethanoic acid.
29. 20 cm^3 of 0.1 M ethanoic acid with 0.1 M potassium hydroxide.

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30. The solubility of silver chloride (AgCl) is $1.41 \times 10^{-5} moldm^{-3}$. The solubility product of this compound is

A 2.82×10^{-5}
B 1.99×10^{-5}
C 1.99×10^{-10}
D 0.70×10^{-5}
E 2.82×10^{-10}

Questions 31 and 32 require the following information:
The solubility product of PbI_2 is 7.9×10^{-9}.

31. The solubility of PbI_2 in water is, in $moldm^{-3}$,

A 1.25×10^{-3}
B 1.99×10^{-3}
C 8.89×10^{-5}
D 1.98×10^{-9}
E 3.95×10^{-9}

32. The solubility of PbI_2 in 0.10M NaI is, in $moldm^{-3}$,

A 7.9×10^{-11}
B 7.9×10^{-10}
C 7.9×10^{-9}
D 7.9×10^{-8}
E 7.9×10^{-7}

Questions 33 and 34 concern the following equations.

A $N_2 + 3H_2 \rightarrow 2NH_3$
B $Cu + CuCl_2 \rightarrow 2CuCl$
C $Zn + 2HCl \rightarrow ZnCl_2 + H_2$
D $Cu(NH_3)^{2+} \rightarrow Cu^{2+} + 2NH_3$
E $Fe + CuSO_4 \rightarrow FeSO_4 + Cu$

33. Which is **NOT** a redox reaction?
34. Which is a disproportionation reaction?

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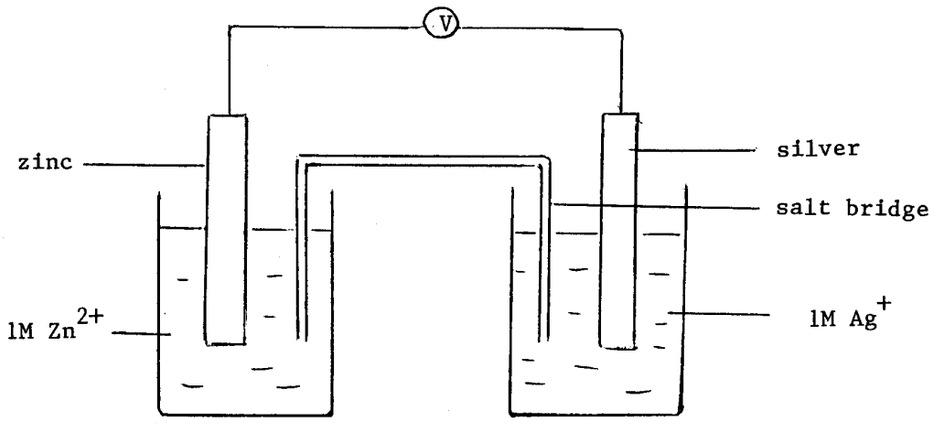
35. Which set shows sulphur in order of **INCREASING** oxidation number?

A HS^-, H_2SO_4, SO_2.
B S, H_2S, SO_2.
C H_2S, HSO_3^-, HSO_4^-.
D HSO_4^-, SO_3^{2-}, S
E SO_3, SO_2, S

36. Which statement is **FALSE** for a voltaic cell?

A The current consists of a flow of electrons in the external circuit and a flow of ions through the electrolyte.
B Cations migrate towards the cathode.
C The cathode is positively charged.
D Oxidation occurs at the cathode.
E A redox reaction takes place in the cell.

Questions 37 to 40 refer to the following diagram of a cell.



Some standard electrode potentials are :-

			E^0/V
$Ag^+ + e^-$	→	Ag	+0.80
$Cu^{2+} + 2e^-$	→	Cu	+0.34
$Zn^{2+} + 2e^-$	→	Zn	-0.76
$Mg^{2+} + 2e^-$	→	Mg	- 2.36

Changes can be made to the cell with the following possible results.

	e.m.f of cell	Direction of flow of electrons
A	Increased	unchanged
B	Increased	reversed
C	Unchanged	unchanged
D	Decreased	unchanged
E	Decreased	reversed

Select, from A to E, the change which would occur when

37. the silver electrode is replaced by a copper electrode in 1M Cu^{2+}.
38. the zinc electrode is replaced by a magnesium electrode in 1M Mg^{2+}.
39. the zinc electrode is replaced by a copper electrode in 1M Cu^{2+}.
40. the silver electrode is replaced by a silver electrode of greater surface area.

SECTION B: Answer ALL questions in the spaces provided in the question paper.

1. The rate law for the reaction P + Q → products is $R = k[P][Q]^2$ with a rate constant of $1.2 \times 10^{-5} M^{-2} s^{-1}$.

   a] Find the rate of the reaction the instant $20.0 cm^3$ of 0.25M P is mixed with $30.0 cm^3$ of 0.15M Q. [2 marks]

   b] What is the value of the rate constant if the concentration of P is doubled and the concentration of Q is kept constant? [1mark]

2. a] Write an expression for K_w, the ionic product of water. [1 mark]

b](i) Given the value of K_w is 1.0×10^{-14} at 25^0C and 51.3×10^{-14} at 100^0C, state whether the ionisation of water is an **endothermic** or an **exothermic** process. Justify your answer. [1 mark]

(ii) Explain why pure boiling water ,at 1 atm pressure, has a pH of 6.1. [2 marks]

3. Use the following information wherever necessary.

$K_w = 1.0 \times 10^{-14}$
$K_a(HCOOH) = 1.8 \times 10^{-4}$
$K_a(HIO_3) = 1.7 \times 10^{-1}$
$K_b NH_3) = 1.8 \times 10^{-5}$

Find the pH of the following solutions:

a] 0.01M hydrochloric acid (HCl) which is a strong acid. [1 mark]

b] 0.01M methanoic acid (HCOOH) which is a weak acid. [3 marks]

c] 0.01M iodic(v) acid (HIO_3) which is a moderately strong acid. [3 marks]

d] 0.01M sodium hydroxide (NaOH) which is a strong base. [1 mark]

e] 0.01M ammonia (NH_3) which is a weak base. [3 marks]

f] A mixture prepared by mixing 30.0cm^3 of 0.01M HCl with 30.0cm^3 of 0.01M NaOH. [2 marks]

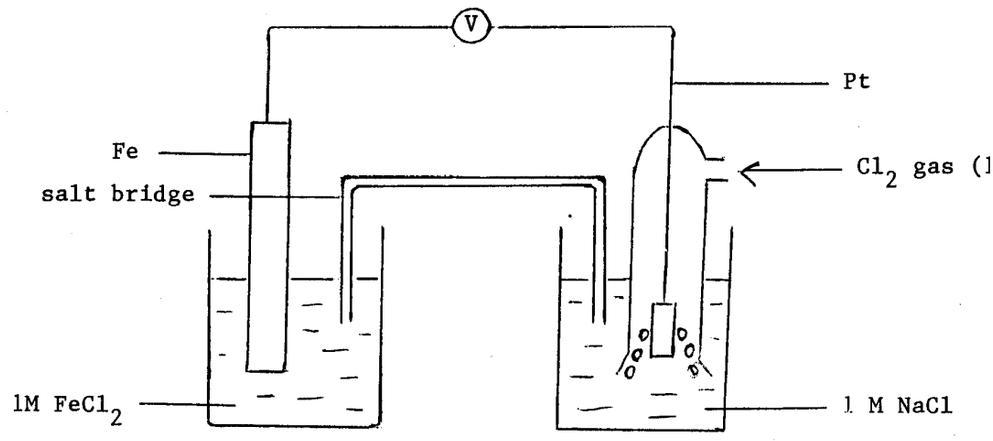
g] A mixture prepared by mixing 30.0cm^3 of 0.01M HCl with 20.0cm^3 of 0.01M NaOH. [3 marks]

h] A mixture prepared by mixing 20.0cm^3 of 0.01M HCl with 20.0cm^3 of 0.01M NH_3. [4 marks]

i] A mixture prepared by mixing 30.0cm^3 of 0.01M HCOOH with 20.0cm^3 of 0.01M NaOH. [4 marks]

4. Use the following table of standard redox potentials wherever necessary.

	E^0/V
$Cl_2 + 2e^- \rightarrow 2Cl^-$	+1.36
$Fe^{3+} + e^- \rightarrow Fe^{2+}$	+0.77
$2H^+ + 2e^- \rightarrow H_2$	0.00
$Fe^{2+} + 2e^- \rightarrow Fe$	-0.44



a] Write a cell notation for the cell represented by the diagram shown.[2 marks]

b] Label the cathode and the anode on the diagram. [1 mark]

c] Find the cell potential. [1 mark]

d] Write an equation for the cell reaction. [2 marks]

e] State two functions of the salt bridge. [2 marks]

f] i) Justify the assumption that a reaction between hydrogen gas and iron(111) nitrate is thermodynamically feasible. [1 mark]

ii) How can you explain the fact that no observable reaction takes place when hydrogen gas is bubbled through iron(111) nitrate solution at room temperature? [2 marks]

a] Sulphur(IV) oxide, SO_2, gas can be identified by its ability to decolourise **acidified** purple potassium manganate(VII), $KMnO_4$, solution. In this reaction sulphate(VI) ions, SO_4^{2-}, and Mn^{2+} ions are formed. Write a balanced **ionic** equation for this reaction by the half cell method. [4 marks]

b] The nitrate(V) ion, NO_3^-, can be identified by the evolution of ammonia gas, NH_3, when powdered aluminium(Al) is added to an **alkaline** solution of a nitrate. The aluminium metal forms the complex ion $Al(OH)_4^-$ in this reaction. Write a balanced **ionic** equation for this reaction by the half cell method. [4 marks]

END OF EXAMINATION