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INSTRUCTIONS TO CANDIDATES:

This examination paper consists of 35 questions on 8 pages. The paper consists of two sections. Section A contains 30 multiple-choice questions. Section B contains 5 structured questions. Specific directions are given at the beginning of each section. Students are allowed to use calculators during this examination.

You may find the following information useful. Use the following information where appropriate:
$R = 8.31\ J\ mol^{-1}\ K^{-1}$ or $0.0821\ atm\ dm^3\ mol^{-1}\ K^{-1}$ $K_w = 1x10^{-14}$ $K_p = K_c (RT)^{\Delta n\ gas}$

SECTION A: Multiple Choice Questions

This section contains 25 multiple choice questions.: Each question is followed by 5 answers. Select the answer that best fits. Mark your answer on the multiple choice answer sheet that has been provided for you. Each question is worth one mark.

1. Consider the following reaction :

$$2\ A + B \rightarrow 2\ C$$

at constant temperature. In several experiments, it was found that when the the concentration of A was doubled, and the the concentration of B was halved, initial rate rate was unchanged.Which of the following rate laws is consistent with this this observation ?

A $R = k\ [A]^2[B]$
B $R = k\ [A]^2[B]^2$
C $R = k\ [A][B]^2$
D $R = k\ [A^2]$
E $R = k\ [A]2[B]$

2. A first-order reaction is known to have a half-life of 20 minutes. *Approximately* what amount of an original sample will remain after 73 minutes?

A greater than one-half
B. less than one-half but greater than one-third
C. less than one-third but greater than one-fourth
D. less than one-fourth but greater than one-eighth
E. less than one-eighth but greater than one-sixteenth

3. The presence of a catalyst increases he rate of a chemical reaction by

A. increasing the frequency of molecular collisions
B. changing the molecular geometry of a collision between reactant molecules
C. providing an alternate reaction pathway, requiring less activation energy
D. increasing the energy of the molecules when they collide
E. decreasing the particle size of the reactant molecules

4. The following mechanism has been proposed for the decomposition of hydrogen peroxide:

Step (i)

$H_2O_2\ (aq) + I^-\ (aq) \rightarrow H_2O\ (l) + IO^-\ (aq)$ slow

Step (ii)

$H_2O_2\ (aq) + IO^-\ (aq) \rightarrow H_2O\ (l) + O_2(g) + I^-\ (aq)$ fast

Which statement is **NOT** consistent with this proposed mechanism?

A IO^- is a reaction intermediate.
B I^- is a catalyst.
C The rate-determining step is bimolecular.
D The reaction is first order with respect to H_2O_2.
E The reaction is first order with respect to O_2

5. For which equilibrium system, at constant temperature, will increasing the pressure cause the equilibrium to shift to the **left**?

A $2\ CO\ (g) + O_2\ (g) \rightleftharpoons CO_2\ (g)$
B $C\ (s) + O_2\ (g) \rightleftharpoons CO_2\ (g)$
C $COCl_2\ (g) \rightleftharpoons CO\ (g) + Cl_2\ (g)$
D $N_2\ (g) + 3\ H_2\ (g) \rightleftharpoons 2\ NH_3\ (g)$
E $CaO\ (s) + CO_2\ (g) \rightleftharpoons CaCO_3\ (s)$

6. Ammonium hydrogen sulphide is heated in a sealed container until the equilibrium described below is established.

$NH_4HS(s) \rightleftharpoons H_2S(g) + NH_3(g)$ If the total pressure at equilibrium is 0.53 atm., what is the value of K_p for the system ?

A 0.265
B 0.28
C 0.070
D 1.06
E 0.079

7. Solid HgO, liquid Hg, and gaseous O_2 are placed in a glass bulb and allowed to reach equilibrium at a constant temperature.

$2\ HgO\ (s) \leftrightarrow Hg\ (l) + O_2\ (g).\ \Delta H = +43.3$ kcal.

The mass of Hg in the bulb can be increased by

A adding some HgO.
B removing some O_2.
C reducing the volume of the bulb.
D lowering the temperature.
E adding some O_2.

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8. According to the Bronsted-Lowry definition, an **base** is a substance which accepts

A hydrogen atom.
B hydrogen ion.
C hydrogen molecule.
D hydride ion.
E hydroxide ion.

9. Which does NOT constitute an acid/base conjugate pair?

A HSO_4^-/ SO_4^{2}
B HNO_3/HNO_2
C NH_4^+/ NH_3
D H_3O^+/ H_2O
E HNO_2/ NO_2^-

10. A salt solution has a pH of 7.7. The concentration of H^+ ions in this solution is closest to

A 2×10^{-8} M
B 2×10^{-7} M
C 7×10^{-7} M
D 7×10^{-8} M
E 8.9×10^{-1} M

11. A salt solution has a pH of 7.9. Which of the following pairs of compounds would be most likely to produce a salt of this pH ?

A Hydrochloric acid & potassium hydroxide
B Nitric acid & ammonia
C Ethanoic acid & sodium hydroxide
D Sulphuric acid & copper (II) oxide
E Hydrochloric acid & iron (II) hydroxide

12. Predict the pH of a solution in which the concentrations of H_3O^+ and OH^- are equal.

A 7
B 0
C 14
D 1×10^{-7}
E 1×10^{-14}

13. The pH of 2.5×10^{-4} M KOH is closest to

A 1
B 4
C 6
D 10
E 14

14. What mass of solid KOH (RFM = 56.0) must be added to 400 cm^3 of 0.050 M HNO_3 in order to obtain a solution of pH 7.0?

A 1.12 g
B 5.60 g
C 56.0 g
D 112 g
E 200 g

15. 0.1M solutions of each of the following salts were prepared. Which salt would be expected to produce a solution with the **lowest** pH?

A KNO_3
B $Mg(NO_3)_2$
C $Al(NO_3)_3$
D $Ca(NO_3)_2$
E $Ba(NO_3)_2$

16. Which set shows the substances in order of **increasing** acid strength?

A HF, HBr, HCl.
B H_2SO_4, H_2SO_3, HSO_4^-.
C HCl, HBr, HF
D HSO_4^-. H_2SO_3, H_2SO_4,
E HNO_3, HNO_2

17. Identify the acid/base conjugate pair.

A H_2SO_4/ SO_4^{2-}
B HNO_3/HNO_2
C NH_4^+/ NH_3
D H_2O /H_2O_2
E HNO_2/ NO_3^-

Questions 18 to 21 refer to the following solutions all at a molarity of 1×10^{-3} M

A $HClO_4$
B NaOCl
C $FeCl_3$
D NaCl
E NaOH

Select from A to E,

18. The solution which would have the lowest pH. A

19. The solution which would have the highest pH E

20. The solution which would have a pH between 3 and 6.9. C

21. The solution which would have a pH between 7 and 12. B

22. A saturated solution of silver phosphate (Ag_3PO_4) contains 1.5×10^{-5} mol dm^{-3} Ag^+ ions. The solubility product of this compound is

A $(1.5 \times 10^{-5})^4$
B $(4.5 \times 10^{-5})^3 (1.5 \times 10^{-5})$
C $(4.5 \times 10^{-5})^3 + (1.5 \times 10^{-5})$
D $4(1.5 \times 10^{-5})$
E $4(1.5 \times 10^{-5})^3$

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23. The solubility products for five salts is given below. Which of the salts has the greatest molar solubility in aqueous solution?

A $BaSO_4$, $K_{sp} = 8.7 \times 10^{-10}$
B CuS, $K_{sp} = 6.0 \times 10^{-36}$
C ZnS, $K_{sp} = 1.2 \times 10^{-23}$
D $SrSO_4$, $K_{sp} = 3.5 \times 10^{-7}$
E AgCl, $K_{sp} = 1.8 \times 10^{-10}$

24. In which compound does oxygen carry an oxidation number of +2 ?

A H_2O
B H_2O_2
C F_2O
D Na_2O
E CO_2

25. All of the following mixtures result in the formation of a buffer solution *except*

A. Equal volumes of 0.10 *M* CH_3COOH and 0.10 *M* $NaCH_3CO_2$
B 100 mL of 0.10 *M* CH_3COOH and 50 mL of 0.10 *M* NaOH
C 100 mL of 0.10 *M* CH_3COOH and 100 mL of 0.10 *M* NaOH
D 50 mL of 0.10 *M* $NaHCO_3$ and 100 mL of 0.10 *M* Na_2CO_3
E 50 mL of 0.10 *M* NH_3 and 25 mL of 0.10 *M* HCl hydroxide

26. Consider the voltaic cell,

$Ni|Ni^{2+}(1\ M)||Hg_2^{2+}(1\ M)|Hg$. Which substance is considered the reducing agent in the cell reaction?

A. Ni
B. Ni^{2+}
C Hg
D Hg_2^{2+}
E can not be determined without additional data

27. A voltaic cell consists of a copper electrode immersed in a solution of 1.0 M copper(11) chloride and a zinc electrode immersed in a solution of 1.0 M zinc nitrate. The two half cells are connected by means of a salt bridge.

Given the standard electrode potential (E^0) values:

Cu^{2+}/Cu +0.34V
Zn^{2+}/Zn -0.76V

Which statement is **false**?

A The copper electrode is the cathode.
B The mass of the zinc electrode decreases during discharge.
C The concentration of Cu^{2+} decreases during discharge.
D The cell potential is zero when the concentration of Cu^{2+} is equal to the concentration of Zn^{2+}.
E Electrons flow through the external circuit from the zinc electrode to the copper electrode

28. For the cell reaction,

$3\ VO_2^+ + 6\ H^+ + Al \rightarrow 3\ VO^{2+} + Al^{3+} + 3\ H_2O$ what is the value of ***n***, the number of moles of electrons exchanged in the reaction?

A 7
B 6
C 4
D 3
E 2

29. Select the species whose highlighted atom has the highest oxidation number of all the species shown..

A ***Mn***O_2
B Na_2***Mn***O_4
C $MgCO_3$
D ***I***O_3^-, 5+
E ***Cl***O_4^-, 7+

30. The standard cell voltage for the following cell is +0.61 V.

$Tl|Tl^+||Cl^-|Hg_2Cl_2|Hg$

If the standard reduction potential for the Tl^+/Tl redox couple is –0.34 V, what is the standard reduction potential of the $Hg_2Cl_2/Cl^-/Hg$ redox couple?

A +0.27 V
B –0.27 V
C –0.95 V
D +0.95 V
E +0.61 V

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

Use the following information where appropriate:
$R = 8.31\ J\ mol^{-1}\ K^{-1} = 0.0821\ atm\ dm^3\ mol^{-1}\ K^{-1}$
$K_w = 1 \times 10^{-14}$

$K_a(NH_4^+) = 6.3 \times 10^{-10}$

$K_w = 1 \times 10^{-14}$ The Henderson Hasselbach equation : $pH = pK_a + \log \frac{[base]}{[acid]}$

$K_a(CH_3COOH) = 1.8 \times 10^{-5}$

1. RATES OF REACTION

The following experimental data was collected for the reaction below.

$2ClO_2(aq) + 2OH^-(aq) \rightarrow ClO_3^-(aq) + ClO_2^-(aq) + H_2O(l)$

All experiments were conducted at the same temperature.

	initial $[ClO_2]$/M	initial $[OH^-]$/M	initial rate of formation ClO_3^- in M s^{-1}
exp 1	1.5×10^{-2}	1.5×10^{-2}	3.88×10^{-4}
exp 2	3.0×10^{-2}	1.5×10^{-2}	1.55×10^{-3}
exp 3	1.5×10^{-2}	3.0×10^{-2}	7.76×10^{-4}

A. Write a rate law for the reaction (1)

B. Find the value of the rate constant, k. (3)

C. Why was it necessary to carry out the 3 experiments at the same temperature? (1)

D. Calculate the initial rate of reaction the instant $20cm^3$ of 0.10M ClO_2 is mixed with $30cm^3$ of 0.40M OH^-. (3)

E. If the reaction was carried out at a higher temperature, what effect would there be on the activation energy? (1)

F. In a fourth experiment, a substance X, was added to the mixture. It was found to increase the reaction rate. However the concentration of substance X at the end of the experiment was the same as at the beginning. How do you account for these observations? (2)

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2.GENERAL EQUILIBRIUM

At 298 K , Kc for the rxn $N_2O_4(g) == 2NO_2(g)$ is 4.61×10^{-3}. A sample containing 0.065 mol of $N_2O_4(g)$ was placed in a 1.0 dm^3 vessel and allowed to come to equilibrium with NO_2 at 298K.

A. Calculate the molar concentration of each gas at equilibrium (4)

B. What effect would there be on equilibrium position if 0.1 mol NO_2 was added ? (1)

C. Justify your answer , with reference to Le Chatelier's Principle. (2)

D. State the effect, if any, of an increase in temperature on the value of the equilibrium constant Kc., giving a reason. H = +ve (2)

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3. ACID- BASE EQUILIBRIA

A. For each pair of substances given, underline the substance which will produce the solution of lower pH , assuming all solutions are at a concentration of 0.10 M. In each case give a reason for your answer, with equations and/ or Lewis structures to support your answer.

a) HNO_2 and HNO_3 (2)

c) HF and HBr. (2)

B. A 25.0 cm^3 aliquot of 0.20 M CH_3COOH solution was titrated with 0.20M KOH solution. Calculate the pH of the titration mixture when:

i. 5.00 cm^3 of KOH(aq) has been added. (3)

ii. 25.0cm^3 of KOH(aq) has been added. (3)

iii. 35.0cm^3 of KOH (aq) has been added. (3)

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B. Benzoic acid C_6H_5COOH is a monoprotic acid with a pKa value of 4.18.
i.Calculate the concentration of all species present in a 0.40 M solution of the acid. (4)

ii. What is the pH of a 0.40M solution of benzoic acid ? (2)

C.i. The pH of 0.15 M sodium propanoate , C_2H_5COONa is 9.02. Calculate the pK_b of the propanoate ion. (3)

ii. Explain/ define the term buffer, and state the name or chemical formula of a substance that could be mixed with sodium propanoate to create a buffer. (3)

4.SOLUBILITY EQUILIBRIA

A. The Ksp for magnesium hydroxide $Mg(OH)_2$ is 1.2×10^{-11}.
Calculate the molar solubility of $Mg(OH)_2$ in distilled water. (4)

B. The molar solubility of $Mg(OH)_2$ in 0.10 M $Mg(NO)_3$ is less than the solubility in water. How do you account for this difference in solubility ? (3)

Explain the term **bidentate ligand** and give one example. (2)

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5. REDOX REACTIONS

A. i. Draw and **label** the Daniel Cell described by the cell notation below: (4)
Zn(s)I Zn^{2+}(aq,1M) II Cu^{2+}(aq,1M)ICu(s)

ii. State/explain the purpose of the salt bridge. (1)

B.Write a balanced ionic equation for the cell reaction.

(2)

C. Calculate the cell potential, given that the standard state reduction potentials for Zn^{2+} and Cu^{2+} are -0.76 V and + 0.34 V respectively. (3)

D. The following reaction takes place in an acid medium.

$$S_2O_6^{2-}(aq) + HClO_{2(g)} \rightarrow SO_4(aq) + Cl_2(g)$$

Derive a balanced ionic equation for the reaction, by writing suitable half equations and then combining them. (3)

E. The following reaction takes place in a basic medium.

$$Bi_2O_3(s) + OCl^-(aq), \text{----} > BiO_3^-(aq) + \text{chloride } Cl^-(aq)$$

Derive a balanced ionic equation for the reaction, by writing suitable half equations and then combining them.

(3)

THIS IS THE END OF YOUR C225 FINAL EXAMINATION.