Part I
Total Value: 50%

Instructions: Shade the letter of the correct answer on the computer scorable answer sheet provided.

1. Which theory is based on the concept that all matter consists of particles in constant motion?

   (A) Arrhenius
   (B) Bohr
   (C) collision
✓ (D) kinetic molecular

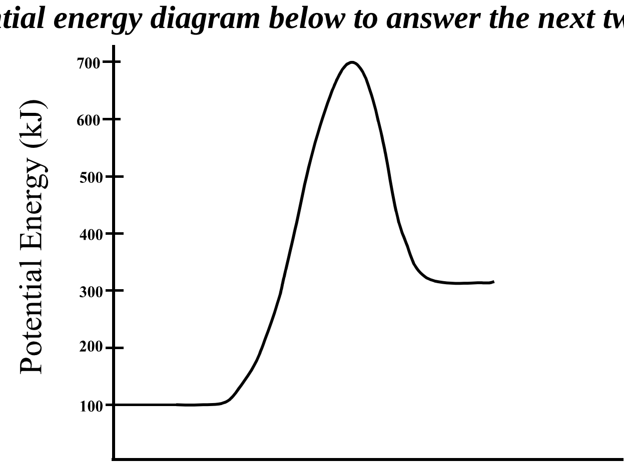
2. Which factor explains why potassium usually reacts faster than sodium?

   (A) concentration
✓ (B) nature of reactants
   (C) surface area
   (D) temperature

3. What increases the rate of a chemical reaction without being consumed?

   (A) activated complex
✓ (B) catalyst
   (C) reactant
   (D) reaction intermediate

Use the potential energy diagram below to answer the next two questions.



4. What is the activation energy for the forward reaction?

   (A) 100 kJ
   (B) 300 kJ
✓ (C) 600 kJ
   (D) 700 kJ

5. What is the heat of reaction for the reverse reaction?

   (A) -600 kJ
✓ (B) -200 kJ
   (C) 200 kJ
   (D) 600 kJ

6. Which are equal in a dynamic equilibrium?

(A) activation energy of the forward and reverse reactions are equal
(B) concentration of reactants and products are equal
(C) moles of reactants and products are equal
✓ (D) rate of the forward and reverse reactions are equal

7. Which will affect the value of K?

(A) adding a catalyst
(B) adding reactants
✓ (C) decreasing temperature
(D) decreasing volume

8. When the concentration of A is increased in the equilibrium below, it takes 100 minutes to reestablish the equilibrium. Which best describes the equilibrium system 60 minutes after substance A was added?

$$A \rightleftarrows B$$

(A) [A] > [B]
(B) [A] < [B]
✓ (C) forward rate > reverse rate
(D) forward rate < reverse rate

9. What is the equilibrium expression for the following system?

$$4\ Fe(s) + 3\ O_2(g) \rightleftharpoons 2\ Fe_2O_3(s)$$

(A) $K_{eq} = [O_2]^3$

✓ (B) $K_{eq} = \dfrac{1}{[O_2]^3}$

(C) $K_{eq} = \dfrac{[Fe_2O_3]^2}{[Fe]^4[O_2]^3}$

(D) $K_{eq} = \dfrac{[2Fe_2O_3]}{[4Fe]\ [3O_2]}$

10. Which will cause the equilibrium below to shift to the right?

$$CH_3Cl(aq) + OH^-(aq) \rightleftharpoons CH_3OH(aq) + Cl^-(aq)$$

(A) adding KCl
✓ (B) adding NaOH
(C) removing CH_3Cl
(D) removing OH^-

11. Given the equilibrium concentrations below, what is the value of K_{eq} for

$N_2(g) + O_2(g) \rightleftharpoons 2NO(g)$?

$[N_2(g)] = 0.10$ mol/L , $[O_2(g)] = 0.20$ mol/L, $[NO(g)] = 0.0030$ mol/L

(A) 2.2×10^{-4}

✓ (B) 4.5×10^{-4}

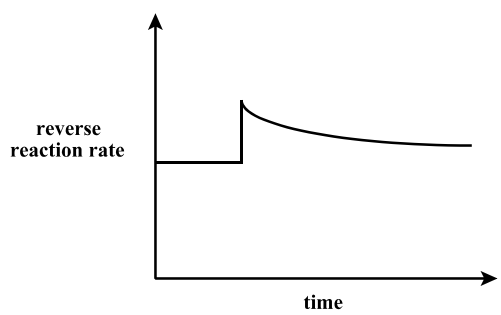
(C) 1.5×10^{-1}

(D) 3.0×10^{-1}

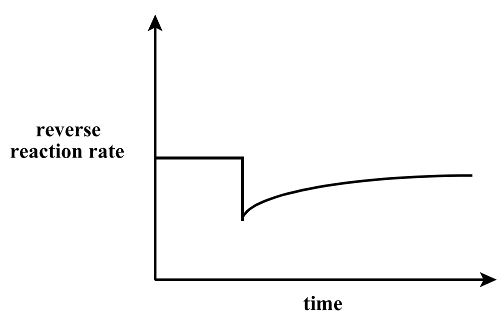
12. Temperature is gradually decreased then held constant in the equilibrium below. Which graph represents the change in the reverse reaction rate?

$$A + B \rightleftarrows C + \text{energy}$$

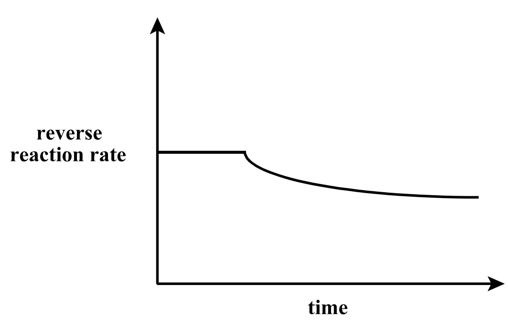
(A)



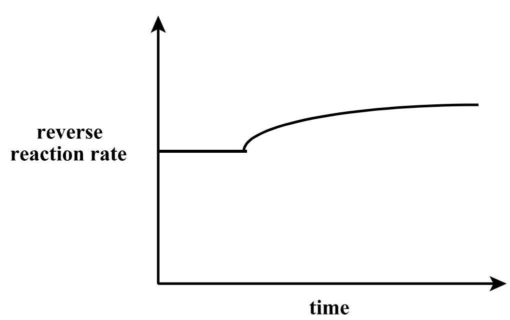
(B)



✓ (C)



(D)



13. Which instrument would be used to monitor the rate of the reaction below in a closed system?

$$Zn(s) + 2HCl(aq) \rightarrow ZnCl_2(aq) + H_2(g)$$

(A) analytical balance
(B) buret
✓ (C) pH meter
(D) volumetric flask

14. Which is true of an Arrhenius base?

(A) accepts a proton
(B) donates a proton
(C) produces $H^+_{(aq)}$
✓ (D) produces $OH^-_{(aq)}$

15. Which represents the equilibrium expression for the ionization of water?

(A) $\left[H_3O^+\right] + \left[OH^-\right]$

(B) $\left[H_3O^+\right] - \left[OH^-\right]$

✓ (C) $\left[H_3O^+\right]\left[OH^-\right]$

(D) $\dfrac{\left[H_3O^+\right]}{\left[OH^-\right]}$

16. Which statement is true about titrations?

(A) The endpoint is the same as the equivalence point.
(B) The endpoint occurs when equal moles of substances react.
✓ (C) The equivalence point occurs when equal moles of substances react.
(D) The equivalence point occurs when the indicator changes color.

17. Which K_a value represents the strongest acid?

(A) 2.3×10^{-13}
(B) 6.2×10^{-8}
(C) 1.7×10^{-5}
✓ (D) 1.2×10^{-2}

18. Solid sodium carbonate, Na_2CO_3 , is used to determine the concentration of a HBr(aq) by titration. What is the role of sodium carbonate in this titration?

(A) catalyst
(B) indicator
✓ (C) primary standard
(D) proton donor

19. What is the conjugate acid of $HAsO_4^{2-}$?

(A) AsO_4^{3-}
(B) AsO_4^{2-}
✓ (C) $H_2AsO_4^-$
(D) $H_2AsO_4^{2-}$

20. Which substance causes red litmus to turn blue?

(A) $CH_3COOH(aq)$
(B) $CH_3OH(aq)$
(C) $HCl(aq)$
✓ (D) $KOH(aq)$

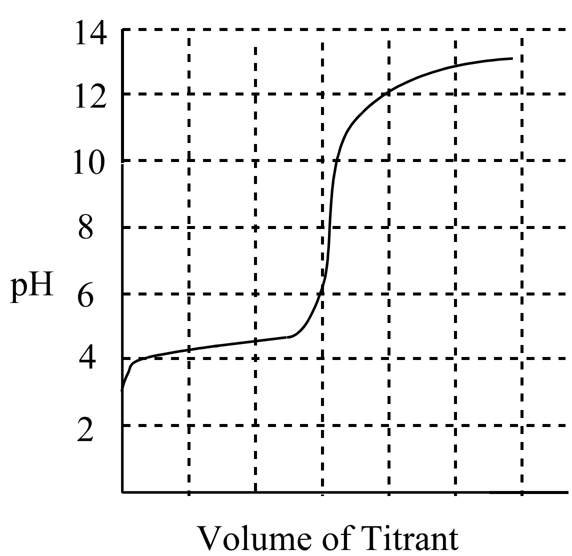
21. Which best describes a basic solution?

(A) $[H_3O^+] = 0$
✓ (B) $[H_3O^+] < [OH^-]$
(C) $[OH^-] = 0$
(D) $[OH^-] < [H_3O^+]$

22. Which acid forms a 0.10 mol/L solution with the highest pH?

✓ (A) acetic acid
(B) nitrous acid
(C) oxalic acid
(D) phosphoric acid

23. Which is a suitable indicator for the titration below?



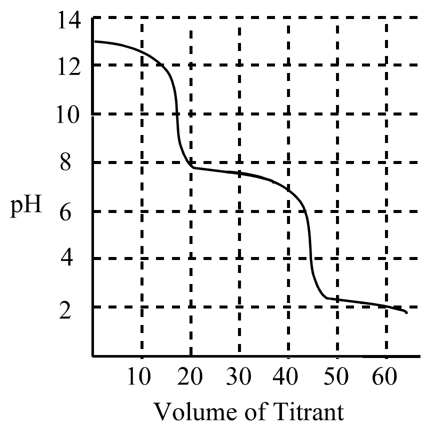
(A) indigo carmine
(B) methyl red
(C) orange IV
✓ (D) thymolphthalein

24. What is the $[H_3O^+(aq)]$ in a solution with pH = 6.50?

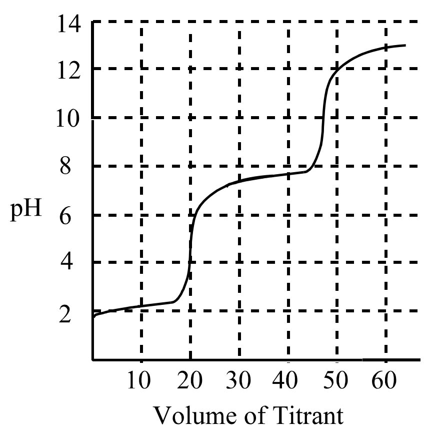
(A) 3.2×10^{-8} mol/L
✓ (B) 3.2×10^{-7} mol/L
(C) 3.2×10^{6} mol/L
(D) 3.2×10^{7} mol/L

25. Which diagram represents the titration of carbonic acid, H_2CO_3 (aq) with a solution of potassium hydroxide, KOH (aq)?

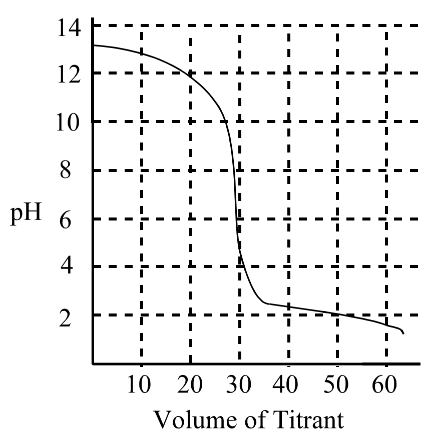
(A)



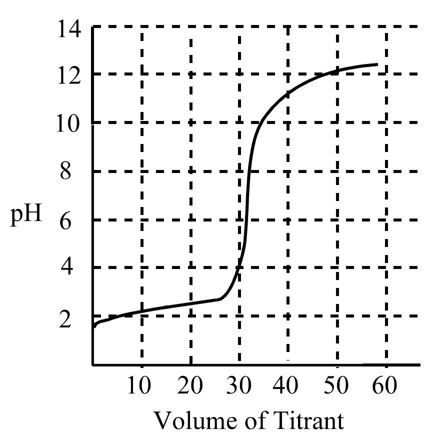
✓ (B)



(C)



(D)



26. Consider the following equilibrium for the chemical indicator phenol red, HInd, at pH = 7.3.

$$\underset{yellow}{HInd} + H_2O \rightleftharpoons H_3O^+ + \underset{red}{Ind^-}$$

If 10.0 mL of 0.10 mol/L NaOH(aq) is added, how will the concentration of H_3O^+(aq) be affected, and what is the color of the resulting solution?

	$[H_3O^+(aq)]$	colour
✓ (A)	decreased	red
(B)	decreased	yellow
(C)	increased	red
(D)	increased	yellow

27. What is the pH of 3.0 mol/L KOH(aq)?

(A) 0.48
(B) 11.00
(C) 13.52
✓ (D) 14.48

28. What happens to $[OH^-]$ and pH of a solution if 1.0 mol/L HCl is added at 25 °C?

✓ (A) $[OH^-]$ decreases and pH decreases.
(B) $[OH^-]$ decreases pH increases.
(C) $[OH^-]$ increases and pH decreases.
(D) $[OH^-]$ increases and pH increases.

29. What is a measure of the average kinetic energy of particles?

(A) heat capacity
(B) joules
(C) specific heat
✓ (D) temperature

30. Which is the correct order of increasing energy changes in terms of magnitude and energies involved?

smallest ⟶ ***largest***

(A) nuclear → chemical → physical
(B) nuclear → physical → chemical
✓ (C) physical → chemical → nuclear
(D) physical → nuclear → chemical

31. What is the symbol used for the energy required to melt one mole of a substance?

(A) ΔH^o_{comb}
✓ (B) ΔH^o_{fus}
(C) ΔH^o_{soln}
(D) ΔH^o_{vap}

32. How is the molar enthalpy change calculated for a chemical reaction?

✓ (A) $\Sigma PE_{products} - \Sigma PE_{reactants}$
(B) $\Sigma PE_{products} + \Sigma PE_{reactants}$
(C) $\Sigma PE_{reactants} - \Sigma PE_{productsts}$
(D) $\Sigma PE_{reactants} + \Sigma PE_{products}$

33. Which is true about all exothermic chemical reactions?

(A) Energy is absorbed.
✓ (B) Energy is released.
(C) ΔH of reaction is positive.
(D) The reaction vessel cools down.

34. How much energy is required to raise the temperature of 7.60 g of copper from 20.0 ^{o}C to 25.0 ^{o}C? (c_{Cu} = 0.385 J/g^{o}C)

(A) 0.585 J
(B) 13.5 J
✓ (C) 14.6 J
(D) 98.7 J

35. What is ΔH^{o}_{comb} of propanol, C_3H_7OH, if burning 10.0 g of propanol releases 336 kJ of energy?

✓ (A) -2020 kJ/mol
(B) -55.9 kJ/mol
(C) -33.6 kJ/mol
(D) -0.0298 kJ/mol

36. Given in the thermochemical reaction below, determine the molar enthalpy of formation for $N_2O(g)$?

$$2\,N_2O(g) \rightarrow 2\,N_2(g) + O_2(g) + 163.3\text{ kJ}$$

(A) -163.3 kJ/mol
✓ (B) -81.6 kJ/mol
(C) 81.6 kJ/mol
(D) 163.3 kJ/mol

37. Which best describes the change in potential energy of water when it undergoes evaporation and condensation?

		evaporation	**condensation**
	(A)	decrease	decrease
	(B)	decrease	increase
✓	(C)	increase	decrease
	(D)	increase	increase

38. Given the ΔH^o_f values below, determine the ΔH^o_{comb} for C_2H_2,?

$$C_2H_2(g) + \frac{5}{2} O_2(g) \rightarrow 2 CO_2(g) + H_2O(g)$$

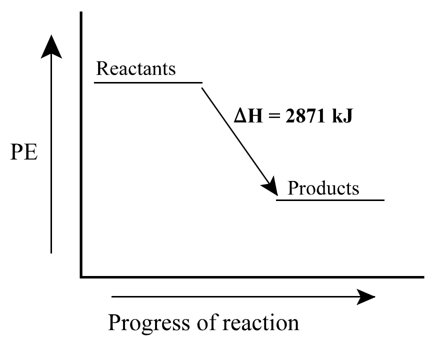
Substance	ΔH^o_f (kJ/mol)
$C_2H_2(g)$	-228
$CO_2(g)$	-394
$H_2O(g)$	-241

✓ (A) - 801 kJ/mol
(B) - 407 kJ/mol
(C) + 407 kJ/mol
(D) + 801 kJ/mol

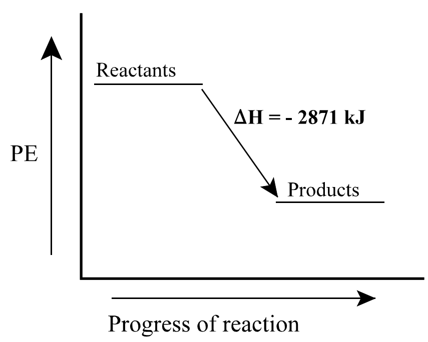
39. Which enthalpy diagram represents the reaction below?

$$C_4H_{10}(g) + \frac{13}{2} O_2(g) \rightarrow 4 CO_2(g) + 5 H_2O(g) + 2871 \text{ kJ}$$

(A)



✓ (B)



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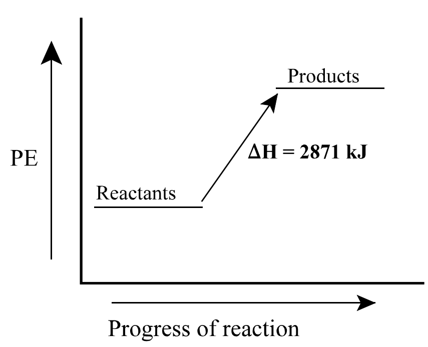
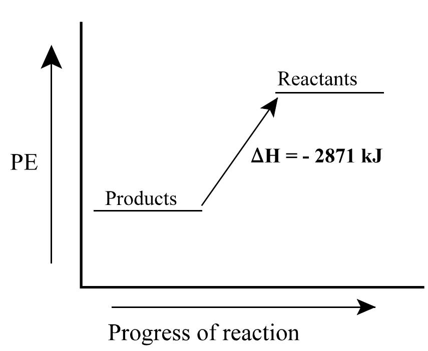
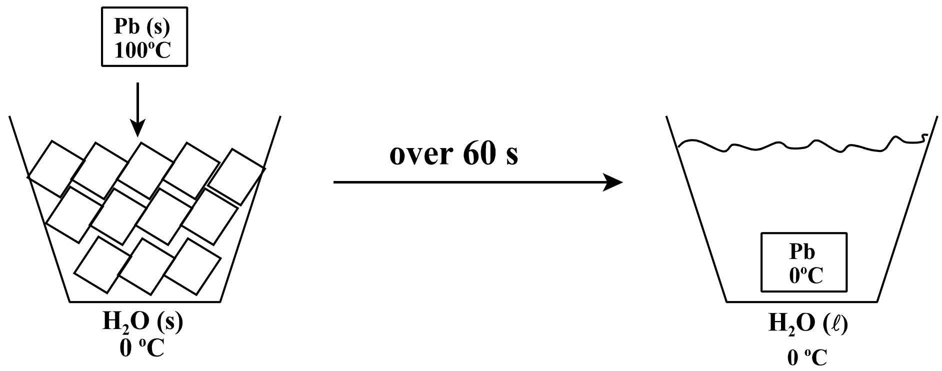


(D)



40. In the experiment below, solid lead at 100 ºC is added to a container of ice at 0 ºC. Which equation can be used to determine the approximate specific heat capacity of lead?



(A) $(mc\Delta T)_{lead} = (mc\Delta T)_{water}$
✓ (B) $(mc\Delta T)_{lead} = -(n\Delta H)_{water}$
(C) $(n\Delta H)_{lead} = (mc\Delta T)_{water}$
(D) $(n\Delta H)_{lead} = -(n\Delta H)_{water}$

41. How does an Fe atom change into an Fe^{2+} ion?

(A) oxidizes and gains 2 electrons
✓ (B) oxidizes and loses 2 electrons
(C) reduces and gains 2 protons
(D) reduces and loses 2 protons

42. What is the oxidation number of magnesium in $MgSO_4$?

(A) - 2
(B) - 1
(C) + 1
✓ (D) + 2

43. Which is an example of a primary electrochemical cell?

(A) car battery
✓ (B) dry cell
(C) H_2/O_2 fuel cell
(D) rechargeable

44. Which process separates water into hydrogen and oxygen?

(A) combustion
(B) electroplating
✓ (C) electrolysis
(D) fusion

45. Which species can be both an oxidizing agent and reducing agent?

(A) Co^{3+}(aq)
(B) Co(s)
✓ (C) Sn^{2+}(aq)
(D) Sn(s)

46. Which atom in the reaction below has a decrease of 3 in oxidation number?

$$K_2Cr_2O_7 + H_2O + S \rightarrow KOH + Cr_2O_3 + SO_2$$

✓ (A) Cr
(B) K
(C) O
(D) S

47. What is true for the reaction, $Sn^{4+} + 2Cl^{-} \rightarrow Sn^{2+} + Cl_2$?

		E° cell (V)	**reaction**
	(A)	- 1.51	non-spontaneous
✓	(B)	- 1.21	non-spontaneous
	(C)	1.51	spontaneous
	(D)	1.21	spontaneous

48. If the half reaction below is balanced in acidic solution, how many moles of hydrogen ions are required to balance the overall equation?

$$Ti \rightarrow TiO_2^{2-}$$

(A) 1
(B) 2
(C) 3
✓ (D) 4

49. Which represents a redox reaction?

✓ (A) $H_2 + I_2 \rightarrow 2HI$

(B) $HCl + NH_3 \rightarrow NH_4Cl$

(C) $H_2O + CO_2 \rightarrow H_2CO_3$

(D) $2NaI + Pb(NO_3)_2 \rightarrow PbI_2 + 2NaNO_3$

50. Ag^{+} reacts spontaneously with Ru but not with Pd. Rank the metals in terms of their strength as reducing agents.

strongest ⟶ ***weakest***
(A) Pd > Ag > Ru
(B) Pd > Ru > Ag
✓ (C) Ru > Ag > Pd
(D) Ru > Pd > Ag

Part II
Total Value: 50%

Instructions: Complete ALL questions in the space provided. Show calculations for numerical problems.

Value

51. Use the table below to answer the following questions.

	Reaction Mechanism	Rate of Reaction	Sign of ΔH
Step 1	$OCl^-(aq) + H_2O(\ell) \rightarrow HOCl(aq) + OH^-(aq)$	fast	negative
Step 2	$HOCl(aq) + I^-(aq) \rightarrow HOI(aq) + Cl^-(aq)$	slow	positive
Step 3	$HOI(aq) + OH^-(aq) \rightarrow H_2O(\ell) + OI^-(aq)$	very fast	negative

1% (a) (i) Write the equation for the overall reaction.

overall: $\mathbf{OCl^-(aq) + I^-(aq) \rightarrow Cl^-(aq) + OI^-(aq)}$

2% (ii) Identify any reaction intermediates and/or catalysts present.

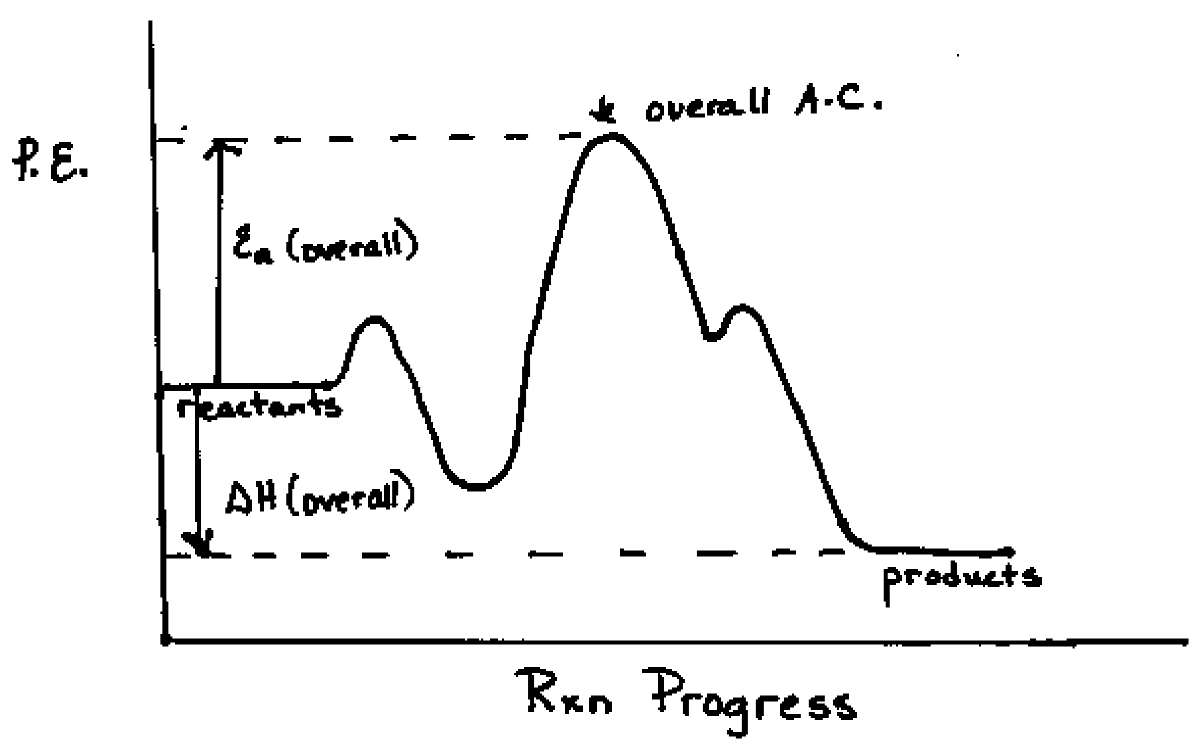
Reaction Intermediate(s): **HOCl , HOI , OH^-**

½ mark @

Catalyst(s): **H_2O**

3% (b) Using the information from the table, and given that the overall reaction is exothermic, draw one possible potential energy diagram for the reaction. On your diagram label:

(i) both axes **½ mark**
(ii) the overall activated complex **½ mark**
(iii) the overall activation energy **½ mark**
(iv) ΔH for the overall reaction **½ mark**
1 mark for shape



Value

51.(c) The system below is initially at equilibrium.

$$HCHCO(g) \rightleftharpoons CO(g) + H_2(g) \quad \Delta H = +5.26 \text{ kJ}$$

2% (i) Explain how a decrease in temperature will affect $[H_2(g)]$?

Rxn is endothermic (energy a reactant); thus shifts left to produce the energy removed by decreasing the temp. (1 mark)

This shift result in H_2 consumed thus a decrease in the $[H_2]$ (1 mark)

2% (ii) Explain how increasing the volume of the reaction vessel will affect [HCHCO(g)]?

Increase in volume ; a decrease in pressure will cause the system to shift to produce more gas molecules; shift right. (1 mark)

This shift results in more HCHCO being formed thus an increase in the [HCHCO] (1 mark)

(d) The equilibrium constant expression for a reaction is:

$$Keq = \frac{[HOCl(g)]}{[H_2O(g)][Cl_2O(g)]} = 9.0 \times 10^{-2}$$

typo: [HOCl] should be squared in the expression ie: $[HOCl]^2$

1% (i) What is the equation for this equilibrium?

$$\mathbf{H_2O\ (g) + Cl_2O\ (g) \rightleftharpoons 2\ HOCl\ (g)}$$

2% (ii) A 1.0 L flask was found to contain 2.0×10^{-2} mol of $H_2O(g)$, 3.0×10^{-2} mol of $Cl_2O(g)$, and 4.0×10^{-3} mol of HOCl(g). Is the system at equilibrium? Justify your answer.

$[H_2O(g)] = 2.0 \times 10^{-2}$ mol/L
$[Cl_2O(g)] = 3.0 \times 10^{-2}$ mol/L
$[HOCl(g)] = 4.0 \times 10^{-3}$ mol/L

$$K = \frac{(4.0 \times 10^{-3} \text{ mol/L})^2}{(2.0 \times 10^{-2} \text{ mol/L})(3.0 \times 10^{-2} \text{ mol/L})} = 0.027$$ **(1 mark)**

Not at eq^{bm} , K $\neq$ 9.0 x 10^{-2} (1 mark)

Value

52.(a) Ink can be prepared by soaking purple cabbage in water. This ink disappears if it is sprayed with dilute vinegar solution.

1% (i) How could you make the ink reappear?

Add a basic material

1% (ii) Write a general equilibrium equation for the cabbage indicator (HCb). Include observed colours.

$$\mathbf{HCb + H_2O \rightleftharpoons Cb^- + H_3O^+}$$ **(½ mark)**

colorless **purple** **(½ mark)**

2% (b) (i) Write an equation for the Bronsted-Lowry reaction between sodium nitrite and potassium hydrogen sulfate?

species present:	Na^+	NO_2^-	K^+	HSO_4^-	H_2O	
	neutral	**B**	**neutral**	**A or B**	**A or B**	**(1 mark)**
strongest		**SB**		**SA**		

auto-ionzed: $\mathbf{NO_2^- + HSO_4^- \rightleftharpoons HNO_2 + SO_4^{2-}}$ **(1 mark)**

1% (ii) Does the equilibrium favor reactants or products?

products

(c) A 25.00 ml sample of 0.200 mol/L hydrochloric acid is titrated with a 0.400 mol/L solution of sodium hydroxide.

3% (i) What is the pH after 6.00 ml of sodium hydroxide solution has been added?

$\mathbf{HCl(aq) + NaOH(aq) \rightarrow H_2O(l) + NaCl(aq)}$ **(½ mark)**

or $\mathbf{H_3O^+(aq) + OH^-(aq) \rightarrow 2\ H_2O(l)}$

$\mathbf{n_{(HCl)} = c\,v = (0.200\ M)\ (0.0250\ L) = 5.00 \times 10^{-3}\ mol}$ **(½ mark)**

$\mathbf{n_{(NaOH)} = c\,v = (0.400\ M)\ (0.00600\ L) = 2.40 \times 10^{-3}\ mol}$

Ratio: HCl : NaOH is 1 : 1 (½ mark)

Excess HCl : 2.40×10^{-3} mol of NaOH reacts with 2.40×10^{-3} mol of HCl leaving 2.60×10^{-3} mol HCl (½ mark)

$\mathbf{c_{(HCl)} = \dfrac{2.60 \times 10^{-3}\ mol}{0.0310\ L} = 0.0839\ mol/L = [H_3O^+]}$ **(½ mark)**

$\mathbf{pH = -\log [H_3O^+] = 1.076}$ **(½ mark)**

1% (ii) What volume of sodium hydroxide is required to reach the equivalence point?

(½ mark)

$\mathbf{v = \dfrac{n}{c} = \dfrac{5.00 \times 10^{-3}\ mol}{0.400\ mol/L} = 0.0125\ L = 12.5\ mL}$

(½ mark)

Value

3% 52.(d) A 0.100 mol/L solution of a weak acid, HA, has a percent ionization of 5.2 %. What is K_b of the conjugate base, A^- ?

	HA	$+ H_2O \rightleftharpoons$	H_3O^+	A^-
I	**0.100**		**0**	**0**
C	**- *x***		**+ *x***	**+ *x***
E	**0.100 - *x***		**+ *x***	**+ *x***

(½ mark)

$[HA]_{change}$ = (0.100 mol/L) (5.2 %) = 0.0052 mol/L = *x* **(½ mark)**

$[HA]_{eq}$ = 0.100 - *x* = 0.100 - 0.0052 = 0.00948 mol/L
$[H_3O^+]_{eq} = [A^-] = x$ = 0.0052 mol/L **(½ mark)**

$$K_a = \frac{[H_3O^+][A^-]}{[HA]} = \frac{(0.0052)^2}{0.0948} = 2.9 \times 10^{-4}$$ **(1 mark)**

one method: $$K_b = \frac{K_w}{K_a} = \frac{1.00 \times 10^{-14}}{2.9 \times 10^{-4}} = 3.5 \times 10^{-11}$$ **(½ mark)**

2% (e) Explain, using appropriate equations, why HCO^{3-}(aq) is considered amphoteric?
typo: should be HCO_3^-

amphoteric means HCO_3^- can act as an acid (donate a proton) or as a base (accept a proton) (1 mark)

as an acid: $HCO_3^-(aq) + OH^-(aq) \rightleftharpoons H_2O(l) + CO_3^{2-}(aq)$
(½ mark)
as a base: $HCO_3^-(aq) + H_3O^+(aq) \rightleftharpoons H_2O(l) + H_2CO_3(aq)$
(½ mark)

5% 53(a). Using the data below, calculate the energy change when 25.0 g of methane, $CH_4(g)$, undergoes complete combustion.

Overall reaction: $CH_4(g) + 2\,O_2(g) \rightarrow CO_2(g) + 2\,H_2O(g)$

$H_2(g) + \frac{1}{2}O_2(g) \rightarrow H_2O(g)$ $\Delta H = -241.8$ kJ/mol

$CO_2(g) \rightarrow C(s) + O_2(g)$ $\Delta H = 393.5$ kJ/mol

$C(s) + 2\,H_2(g) \rightarrow CH_4(g)$ $\Delta H = -74.6$ kJ/mol

$CH_4(g) \rightarrow C(s) + 2\,H_2(g)$ ΔH = 74.6 kJ/mol (1 mark)
$C(s) + O_2(g) \rightarrow CO_2(g)$ ΔH = -393.5 kJ/mol (1 mark)
$2\,H_2(g) + O_2(g) \rightarrow 2\,H_2O(g)$ ΔH = -483.6 kJ/mol (1 mark)

$CH_4(g) + 2\,O_2(g) \rightarrow CO_2(g) + 2\,H_2O(g)$ ΔH_{comb} = -802.5 kJ/mol
(1 mark)

$$n = \frac{25.0\text{ g}}{16.05\text{ g/mol}} = 1.56\text{ mol}$$ **(½ mark)**

$q = n\,\Delta H$
= (1.56 mol) (- 802.5 kJ/mol)
= -1250 kJ
(½ mark)

Value

3% 53.(b) Explain kinetic and potential energy changes that occur in zinc as it is being warmed from 200 ºC to 700 ºC. (melting point of Zn = 420 ºC, boiling point of Zn = 907 ºC)

Zn (s) → Zn (s)

200˚C 420˚C PE constant ; KE increases

Zn (s) → Zn (l)

420˚C 420˚C PE increases; KE constant

Zn (l) → Zn (l)

420˚C 700˚C PE constant ; KE increases

3% (c) 1.26 g of benzoic acid, $C_6H_5COOH(s)$(ΔH_{comb} = 3225 kJ/mol), is burned in a bomb calorimeter. The temperature of the calorimeter and its contents increases from 23.62 ºC to 27.14 ºC. Calculate the heat capacity of the calorimeter.

$$n = \frac{m}{M} = \frac{1.26\text{ g}}{122.13\text{ g/mol}} = 0.0103\text{ mol}$$ **(½ mark)**

$q_{cal} = C\,\Delta T$
$= (C_{cal})(27.14˚C - 23.62˚C)$
$= (C_{cal})(3.52˚C)$
(½ mark)

$q_{rxn} = n\,\Delta H_{comb}$
$= (0.0103\text{ mol})(-3225\text{ kJ/mol})$
$= -33.4\text{ kJ}$
(1 mark)

$q_{sys} = -q_{surr}$
$q_{rxn} = -q_{cal}$
$-33.4\text{ kJ} = -(C_{cal})(3.52˚C)$

$$C_{cal} = \frac{-33.4\text{ kJ}}{-3.52˚C} = 9.45\text{ kJ/˚C}$$ **(1 mark)**

2% 53.(d) Give two reasons why a bomb calorimeter is a better instrument than a soft drink can for determining enthalpies of reaction?

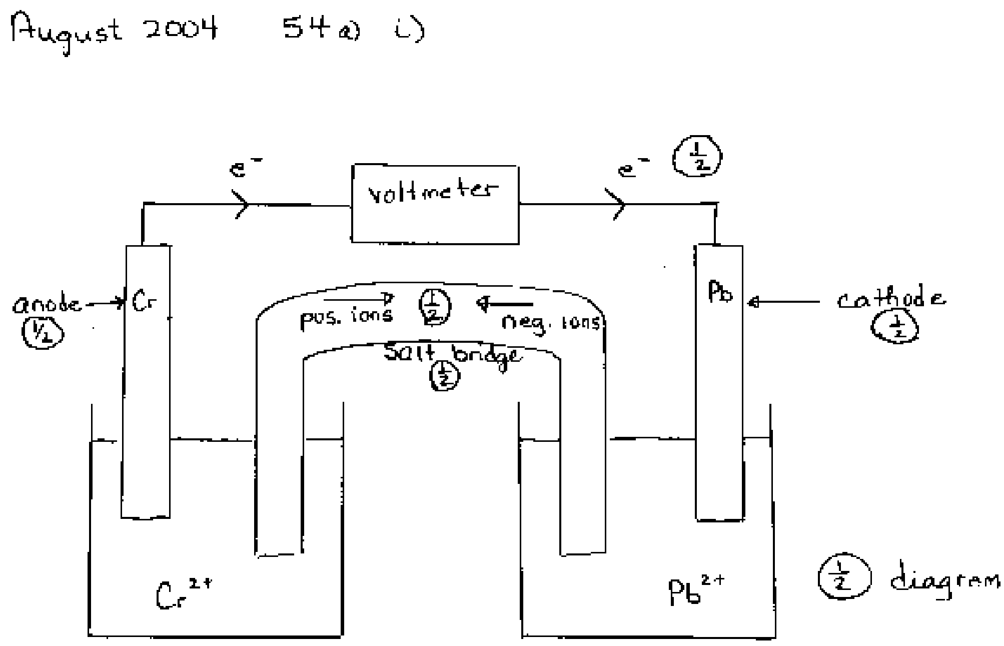
Closed system

- no heat loss (1 mark)

- no mass loss (1 mark)

Value

3% 54.(a) (i) Draw a diagram of the cell represented by Cr(s)|Cr^{2+}(aq)‖Pb^{2+}(aq)|Pb(s). Label the following: anode, cathode, direction of electron flow, direction of ion flow, and the salt bridge.



2% (ii) What is the balanced redox reaction occurring in (i) above?

$$\mathbf{Cr_{(s)} + Pb^{2+}_{(aq)} \rightarrow Cr^{2+}_{(aq)} + Pb_{(s)}}$$

1% (iii) What is E° for this cell?

$$\mathbf{Cr_{(s)} \rightarrow Cr^{2+}_{(aq)} + 2\,e^- \qquad \mathscr{E} = +0.91\ V}$$
$$\mathbf{Pb^{2+}_{(aq)} + 2\,e^- \rightarrow Pb_{(s)} \qquad \underline{\mathscr{E} = -0.13\ V}}$$
$$\mathbf{\mathscr{E}_{cell} = +0.78\ V}$$

4% (b) What current must be applied to an electrolytic cell, containing a solution of $NiCl_2$(aq), to produce 1.50×10^4 g of pure Ni(s) in 24 hours?

$$\mathbf{n\ (Ni) = \frac{m}{M} = \frac{1.50 \times 10^4\ g}{58.71\ g/mol} = 256\ mol}$$ **(½ mark)**

$$\mathbf{Ni^{2+}_{(aq)} + 2\,e^- \rightarrow Ni_{(s)}}$$ **(½ mark)**

$$\mathbf{n\,(e^-) = 256\ mol\ Ni \times \frac{2\ mol\ e^-}{1\ mol\ Ni} = 512\ mol\ e^-}$$ **(½ mark)**

$$\mathbf{Q = n_{e^-}\,F = (512\ mol\ e^-)(96500\ C/mol\ e^-) = 4.94 \times 10^7\ C}$$ **(½ mark)**

$$\mathbf{I = \frac{Q}{t} = \frac{(4.94 \times 10^7\ C)}{(24\ h \times 3600\ s/h)} = \frac{(4.94 \times 10^7\ C)}{86400\ s} = 572\ A}$$ **(½ mark)**

(½ mark)