NAME_____

Final Examination
Form B
December 12, 1997

This examination has fifty questions and ten (10) different pages **including a periodic chart**.
Each question is worth 4 points; 200 possible points.
An * indicates a question for which partial credit will be given.

PLEASE code and write your PID No. NOW on the answer sheet.
Mark your answers to all questions on this examination and on the answer sheet.
Answers will be posted on the web at the end of the examination period.

Please turn in your ANSWER SHEET by RECITATION INSTRUCTOR.
Take the examination with you.
Have a great break! Forget chemistry for a few weeks.

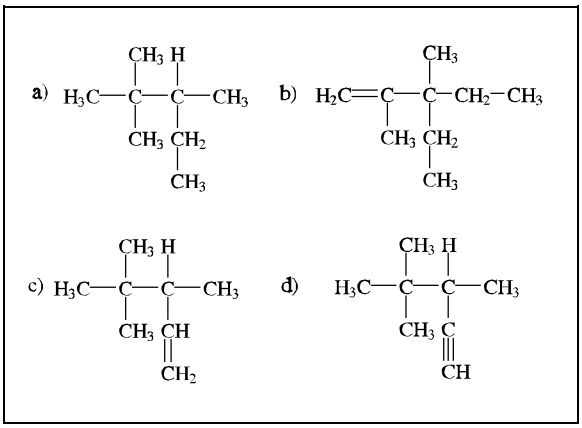
MARK THE **ONE ANSWER you think BEST if more than one is correct**
REMEMBER: WE GRADE ONLY YOUR ANSWER SHEET

Activity Series: Li>K>Ba>Ca>Na>Mg>Al>Mn>Zn>Cr>Fe>Cd>Co>Ni>Sn>Pb>H>Cu>Ag>Hg>Pt>Au

en = ethylenediamine ($H_2N\text{-}CH_2\text{-}CH_2\text{-}NH_2$) = N⌒N
ox = oxalate = ($O_2C\text{-}CO_2^{2-}$) = $O_2CCO_2^{2-}$

Spectrochemical series:
$I^- < Br^- < S^{2-} < [SCN]^- < Cl^- < [NO_3]^- < F^- < [C_2O_4]^{2-} < H_2O < [NCS]^- < NH_3 < en < [NO_2]^- < [CN]^- < CO$
Trans-directing series:
$CN^{1-} > I^- > Br^- > Cl^- > NH_3$

1. The structure of 2,3-dimethyl-3-ethyl-1-pentene is
The correct answer is **b**.



2. The nucleus that results after $^{81}_{37}Rb$ has undergone *electron capture* is

(a)☺ $^{81}_{36}Kr$ (b) $^{81}_{38}Sr$
(c) $^{80}_{37}Rb$ (d) $^{77}_{35}Br$

3. Which statement about the nuclide $^{88}_{35}Br$ is **CORRECT**?

(a) It's stable because it is an odd-odd nuclide.
(b) It's a heavy nuclide, so it probably decays by α emission.
(c) It has an excess of protons, so it probably decays by positron ($_{+1}\beta$) emission.
(d)☺ It has an excess of neutrons, so it probably decays by $_{-1}\beta$ emission.

4. Which molecule **does not** obey the *18-electron rule*?

(a) $[Fe(CO)_5]$ (b) $[H_2Fe(CO)_4]$ (c) $[C_6H_6Cr(CO)_3]$ (d)☺ $[V(CO)_6]$

5. The i.r. stretch frequency for $CO(g)$ is 2143 cm^{-1}. Which statement about the **C-O stretch frequency** in the three *isoelectronic* species, $[Mn(CO)_5]^-$, $[Fe(CO)_5]$, and $[Co(CO)_5]^+$ is **CORRECT**?

(a)☺ The stretch frequency for $[Co(CO)_5]^+$ will be **closest** to 2143 cm^{-1}.
(b) The stretch frequency of all three species will be greater than 2143 cm^{-1}.
(c) The stretch frequency for $[Mn(CO)_5]^-$ will be **closest** to 2143 cm^{-1}.

6. Which statement about transition metal carbonyl complexes is **CORRECT**?

(a) CO *only* forms π-bonds with transition metals.
(b)☺ Electron density from the metal t_{2g} orbitals *back-bonds* into the CO π^* orbitals, weakening the C≡O bond.
(c) Electron density from the C-O π-bonds *back-bonds* into the metal t_{2g} orbitals, weakening the C≡O bond.
(d) Electron density from the C-O σ-bond *bonds* with the metal e_g orbitals and weakens the C≡O bond.

7. The half-life of $^{32}_{15}P$ is about 14 days. About *how many days* will be required before *only* 0.2 g of a 0.8 g ^{32}P remains?

(a) 14 days (b) 56 days (c)☺ 28 days (d) 42 days

8. Which statement about **hydrocarbons** is **CORRECT**?

(a) The molecule $H_3C\text{-}CBr_2I$ is *chiral*.
(b) The molecule $H_2BrC\text{-}CH_2Br$ can be *cis* or *trans*.
(c)☺ A *saturated* hydrocarbon does not have either double or triple bonds.
(d) The general formula for a *cycloalkane* is C_nH_{2n+2}.

9. The *hybridization* of the carbon atoms in the hydrocarbon *ethene*, $H_2C{=}CH_2$, is

(a)☺ sp^2 (b) sp^3 (c) sp (d) sp^4

10. Which statement is **CORRECT**?

(a) Myoglobin has four heme groups and hemoglobin has one.
(b) The iron atom in the heme group is coordinated to *four tetrahedrally-oriented* N atoms.
(c)☺ Myoglobin has a stronger affinity for oxygen than does hemoglobin.
(d) When the iron atom in heme coordinates to oxygen it changes from *low* spin to *high* spin.

11. The transition metal cation that **appears smaller** when coordinated *octahedrally* to strong field CN^{1-} ligands than when coordinated to weak field F^{1-} ligands is

(a) d^3 Cr^{3+} (b) d^2 V^{3+} (c) d^8 Ni^{2+} (d)☺ d^5 Mn^{2+}

12.* When we classify a complex ion as *inert*, we mean it

(a) has a d^6 low-spin electron configuration. (b)☺ exchanges ligands *very slowly*.
(c) is a *low spin* complex ion. (d) is *impossible* to change any of its ligands.

13. We expect *tetrahedral* complex ions to form when

(a) Δ_t exceeds the pairing energy.
(b) the ligands are high (*strong field*) in the spectrochemical series.
(c)☺ the ligands are *large* and low (*weak field*) in the spectrochemical series.
(d) the ligands have *empty* π*-type orbitals.

14.* The d^8 complex ion $[Ni(CN)_4]^{2-}$ was *square planar*. Identify the **CORRECT** *d*-orbital energy diagram.

(a)

___ $d_{x^2-y^2}$
___ d_{z^2}
___ d_{xz}
__ __ d_{xy} d_{yz}

(b)

___ d_{z^2}
___ $d_{x^2-y^2}$
___ d_{xz}
__ __ d_{yz} d_{xy}

(c)☺

___ $d_{x^2-y^2}$
___ d_{xy}
___ d_{z^2}
__ __ d_{xz} d_{yz}

(d)

___ d_{z^2}
___ d_{xy}
___ $d_{x^2-y^2}$
__ __ d_{xz} d_{yz}

15.* The electronegative fluoride ion forms *high spin* octahedral complex ions with Co^{3+} because

(a) its filled *p*-orbitals π-bond with the Co^{3+} t_{2g} orbitals and the fluoride electrons occupy the **antibonding** t_{2g}* orbitals.
(b)☺ its filled *p*-orbitals π-bond with the Co^{3+} t_{2g} orbitals and the Co^{3+} electrons occupy the **antibonding** t_{2g}* orbitals.
(c) it is so electronegative that its electrons don't interact with the Co^{3+} e_g orbitals.
(d) its size prevents it from getting close enough to the Co^{3+} e_g orbitals to create a strong field environment.

16. Which statement about *charge transfer* bands is **CORRECT**?

(a) They are observed only for *tetrahedral* complex ions.
(b)☺ They result when a photon excites an electron from a *ligand* to a *metal* orbital.
(c) They result when an electron excited from a ligand to the central atom returns to the ground state.
(d) They are observed *only* with *strong-field* ligands like CN^{1-}.

17. Use the *trans-directing* series on the cover to determine the product of the reaction of $[Pd(NH_3)_3Cl]^+$ with sufficient I^{1-} ion to replace **one** ligand.

(a) $[Pd(NH_3)_3I]^+$ (b) *cis*-$[Pd(NH_3)_2ICl]$
(c)☺ *trans*-$[Pd(NH_3)_2ICl]$ (d) *trans*-$[Pd(NH_3)_2I_2]$

18. The *ligand field stabilization energy* for the d^7 $[Co(NCS)_4]^{2-}$ ion is

(a) $-4/5\ \Delta_t$ (b)☺ $-6/5\ \Delta_t$
(c) $-9/5\ \Delta_t$ (d) $-12/5\ \Delta_t$

19. Which statement describes *lattice energy* best?

In **ionic bond** formation, lattice energy
(a) is the energy *absorbed* when a mole of $Na^+(g)$ reacts with a mole of $Cl^{1-}(g)$.
(b)☺ and (sometimes) electron affinity are *exothermic* and provide the 'driving force' for the reaction.
(c) *increases* as the size of the cation and anion *increase*.
(d) is the energy *required* to remove electrons from the metal ion.

20. Which statement about *hydrides* is **CORRECT**?

(a)☺ *Salt-like* hydrides form with all *group 1* and some *group 2* elements and contain the H^{1-} anion.
(b) Most *covalent* hydrides react with water to form $H_2(g)$.
(c) B_2H_6 is an *interstitial* hydride.
(d) $CaH_2(s)$ dissolves in water and produces an *acidic* solution.

21.* Identify the **CORRECT** statement about the reaction:

$$[Fe(OH_2)_6]^{3+}(aq) + OCl^{1-}(aq) \rightarrow [Fe(OH_2)_5OH]^{2+} + HOCl(aq)$$

(a) $[Fe(OH_2)_6]^{3+}(aq)$ is the *conjugate base* of $[Fe(OH_2)_5OH]^{2+}(aq)$.
(b) $OCl^{1-}(aq)$ is the *conjugate acid* of $HOCl(aq)$.
(c) This is an example of a *Lewis* acid-base reaction.
(d)☺ In this Brønsted-Lowry acid-base reaction $[Fe(OH_2)_6]^{3+}(aq)$ is a *stronger acid* than $HOCl(aq)$.

22. The *'molecular' shape* of the polyhalide ClF_4^{1-} ion is

(a) octahedral. (b) square pyramidal.
(c)☺ square planar. (d) trigonal bipyramidal.
(e) tetrahedral.

23. Which of the compounds is a *weak* electrolyte?

(a) NaCl (b) LiF (c) Na_2SO_4 (d)☺ $HC_2H_3O_2$

24. Which statement about *electronegativity* is **CORRECT**?

In the periodic chart,
(a) electronegativity increases ↓ and →.
(b) electronegativity increases ↑ and ←.
(c)☺ electronegativity increases ↑ and →.
(d) electronegativity increases ↓ and ←.

25. Which molecule is expected to be *non-polar*?

(a) $COCl_2$ (b)☺ BF_3 (c) O_3 (d) Cl_2O

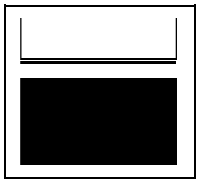
26. Which statement about *main group element ionization energies/electron affinities* is **CORRECT**?

(a)☺ Ionization energies increase from *left to right* across a period with exceptions **at** s^2p^1 and s^2p^4.
(b) Ionization energies increase *down* a group.
(c) The reaction [$E(g) + e^{1-} \rightarrow E^{1-}(g)$ + energy] is more *exothermic* for $K(g)$ than for $Br(g)$.
(d) It is easier to add an electron to $N(g)$ than to $P(g)$.

27. The *electrical conductivity* of a **metal** _____ with *increasing temperature*; that of a **semiconductor** _____ with increasing temperature.

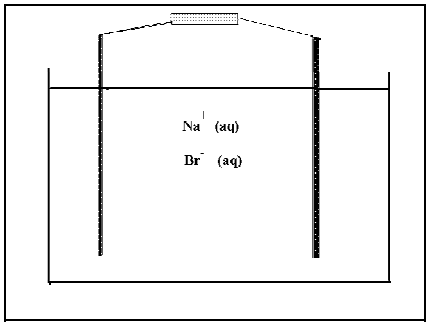
(a) increases, increases (b) increases, decreases
(c)☺ decreases, increases (d) decreases, decreases

28. A band energy diagram is illustrated at the right. The dark area represents a filled band, the light area an empty band. An energy state is located in the region between the filled and empty bands. Identify the **CORRECT** statement.



(a) The diagram represents an *insulating material* such as MgO.
(b) The diagram represents a *metallic* conductor such as Be.
(c) The diagram represents a *p-type* semiconductor such as Ge 'doped' with B.
(d)☺ The diagram represents an *n-type* semiconductor such as Ge 'doped' with P.

29. Which statement about the **electrolysis** cell sketched at the right is **CORRECT**?



(a) $Na(\ell)$ is produced at the **cathode**.
(b) The region around the cathode becomes **acidic**.
(c)☺ Br^{1-} is **oxidized** at the anode.
(d) Electrons move through the solution from the **cathode** to the **anode**.

30. Which reaction is **NOT** considered a *metathesis* reaction.

(a) $LiC_2H_3O_2(aq) + HCl(aq) \rightarrow HC_2H_3O_2(aq) + LiCl(aq)$.
(b)☺ $Cl_2(g) + H_2O(\ell) \rightarrow HCl(aq) + HOCl(aq)$
(c) $Na_2SO_4(aq) + Ba(NO_3)_2(aq) \rightarrow BaSO_4(s) + 2\ NaNO_3(aq)$
(d) $CaS(s) + 2\ HC_2H_3O_2(aq) \rightarrow H_2S(g) + Ca(C_2H_3O_2)_2(aq)$

31. Which statement about *d-block* metal chemistry is **CORRECT**?

(a) $VO(s)$ should be *more acidic* than $V_2O_5(s)$.
(b)☺ The 'lanthanide contraction' causes *5d* elements to be *more dense* than *4d* elements.
(c) Solutions of d^5 Mn^{2+} are *more likely* than those of d^5 Fe^{3+} to show *charge transfer* bands.
(d) The *3d* element that shows the *highest* oxidation state is **Fe**.

32. Which statement about *main group* element chemistry is **CORRECT**?

(a)☺ Most *non-metal halides* react with water (hydrolyze) to produce *acidic* solutions.
(b) Oxides of the *period 2* elements are *more basic* than those of *period 6* elements.
(c) Group 13 compounds are usually good *Lewis bases*.
(d) $XeBr_4$ can be prepared by heating Xe with an excess of $Br_2(\ell)$.

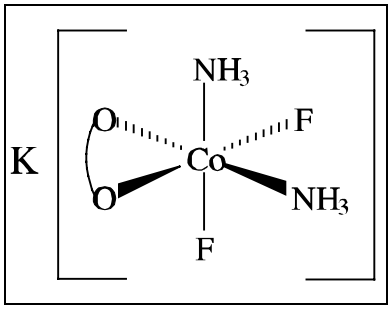
33. The *acid anhydride* of H_3AsO_4 is

(a) As_2O (b) As_2O_3 (c) AsO_2
(d) $HAsO_3$ (e)☺ As_2O_5

34. Which statement about *environmental chemistry* is **CORRECT**?

(a)☺ CO_2 and H_2O in the atmosphere absorb infrared (long wavelength) radiation from the earth and radiate some of it back to earth.
(b) H_3CCF_3, CO_2 and CH_4 are responsible for converting $O_3(g)$ in the stratosphere to $O_2(g)$ and $O(g)$ *without removing* harmful ultraviolet ($240 < \lambda < 310$) radiation.
(c) *Photochemical smog* is caused when $SO_2(g)$ reacts with ozone, $O_3(g)$ in regions where sunlight is abundant.
(d) $CO_2(g)$ and $SO_2(g)$ make *rain acidic*.

35.* The complex ion at the right



(1) has an *optical* isomer (*i.e.*, is chiral).
(2) is a *chelate* complex.
(3) is named: potassium cis-diamminedifluorooxalatocobaltate(III)

(a) Only one of the three statements is correct.
(b) Only statements (1) and (3) are correct.
(c) Only statements (2) and (3) are correct.
(d) Only statements (1) and (2) are correct.
(e)☺ All three statements are correct.

36. The **reaction** that occurs **at the anode** in the lead-storage *when the battery is being charged* is:

(a) $PbO_2(s) + 2\ e + 4\ H^+(aq) + SO_4^{2-}(aq) \rightarrow PbSO_4(s) + 2\ H_2O$
(b) $PbSO_4(s) + 2\ e \rightarrow Pb(s) + SO_4^{2-}(aq)$
(c) $Pb(s) + SO_4^{2-}(aq) \rightarrow PbSO_4(s) + 2\ e$
(d)☺ $PbSO_4(s) + 2\ H_2O \rightarrow PbO_2(s) + 2\ e + SO_4^{2-}(aq) + 4\ H^+(aq)$

37. Which statement about the demonstrations is **CORRECT**?

(a) $Br_2(\ell)$ was *decolorized* instantaneously by cyclohex*ane*.
(b) Light from the projector *dissociated* the $Br_2(\ell)$, enabling it to add to cyclohex*ene*.
(c)☺ $Br_2(\ell)$ added across the double bond in cyclohex*ene*, but had to displace H atoms in cyclohex*ane*.
(d) The 'lake bed effect' demonstration showed that *carbonate-containing* minerals cause lakes to become *acidic*.

38. Which statement about the Zn^{II}-cereal grain demonstration is **CORRECT**?

(a)☺ Phytic acid in cereal grains forms complexes with zinc and may cause zinc deficiency.
(b) Zincon complexes phytic acid more strongly than does divalent zinc.
(c) Zincon present in cereal grains may cause a zinc deficiency.
(d) Zincon complexes Zn^{II} more strongly than does phytic acid.

39. Which statement about the demonstrations is **CORRECT**?

(a) Colors of group 1 metal salts heated in methanol and of vanadium complex ions result from photons *emitted* when electrons in excited energy levels 'drop' to the ground state.
(b)☺ Ca and CaH_2 react with water to produce $H_2(g)$ and $Ca(OH)_2(s)$ and give a *basic* solution.
(c) Once ignited, $Mg(s)$ reacted with $CO_2(s)$ to produce light, $MgCO_3$(s), and MgO 'smoke.'
(d) $N_2(\ell)$ is attracted to the poles of a permanent magnet.

40. H_2 reacts explosively with Cl_2 when the mixture is exposed to a bright light because

(a) the H-H bond is easily broken, producing H· atoms that react with chlorine.
(b) the flash ionizes hydrogen, producing a *proton* that immediately combines with the $Cl_2(g)$.
(c) of the very large H-Cl *lattice energy*.
(d)☺ the Cl-Cl bond is broken by the photoflash and Cl· atoms react with H_2, producing HCl and H· atoms and causing a chain reaction.

41. Which statement about the demonstrations is **CORRECT**?

(a) $MnO_4^{1-}(aq)$ reacts with $HSO_3^{1-}(aq)$ in a *neutral solution* to give green $MnO_4^{2-}(aq)$.
(b) The $CrO_4^{2-}(aq)$ ion is produced when a $Cr_2O_7^{2-}(aq)$ solution is *acidified.*
(c) An acidified $Cr_2O_7^{2-}(aq)$ solution *reduces* H_2O_2 to H_2O.
(d)☺ In an *acidic* medium the $MnO_4^{1-}(aq)$ reacts with $HSO_3^{1-}(aq)$ to produce the *least oxygen rich* product, $Mn^{2+}(aq)$ in this case.

42. Which statement about the reaction of Al with $Br_2(\ell)$ is **CORRECT**?

(a)☺ The reaction started slowly because aluminum is protected by a dense oxide coating.
(b) The reaction produced a shower of sparks as soon as the Al was dropped into the $Br_2(\ell)$.
(c) The reaction started slowly, but once started shot sparks out of the container into the room.

43.* Consider three statements about the demonstrations.

(1) Oxides of both S and P_4 give acidic solutions when dissolved in water.
(2) Mg_2Si reacts with $HCl(aq)$ to give $H_2(g)$, $MgCl_2(aq)$, and $SiCl_4(aq)$.
(3) After being ignited $Al(s)$ reacts violently with $Fe_2O_3(s)$ to give a shower of sparks and $Fe(\ell)$.

(a) All three statements are correct.
(b)☺ Only statements (1) and (3) are correct.
(c) Only statements (2) and (3) are correct.
(d) Only statements (1) and (2) are correct.
(e) Only one of the three statements is correct.

44. Which statement about the demonstrations that involved complex ions is **CORRECT**?

(a)☺ A $[Fe(OH_2)_5F]^{2+}$ solution is colorless because electrons in the F^{1-} ligand are bound too tightly to allow *charge transfer* bands to occur in the visible region of the spectrum.
(b) A $[Fe(OH_2)_5Cl]^{2+}$ solution is colorless because the electronegative Cl^{1-} ligand holds electrons too tightly to allow *charge transfer* bands to occur in the visible region of the spectrum.
(c) Distorted octahedral $[Cu(OH_2)_6]^{2+}$ is *more intensely colored* than tetrahedral $[CuBr_4]^{2-}$.
(d) A $[Fe(OH_2)_6]^{3+}$ solution to which the SCN^{1-} ion is added forms a *brown* precipitate.

45. Which iron salt contains *only **one*** unpaired electron?

(a) $K_4[Fe(CN)_6]\cdot 3\,H_2O$ (b) $FeSO_4\cdot 7\,H_2O$
(c) $Fe_2(SO_4)_3\cdot 9\,H_2O$ (d)☺ $K_3[Fe(CN)_6]$

46. $I_2(g)$ was ejected from a $Zn(s)$ - $I_2(s)$ mixture when water was added to it because

(a) $H_2(g)$ produced when Zn reacts with water 'sweeps' the I_2 from the container.
(b) $I_2(s)$ is insoluble in water and was ejected from the tube when the water was added.
(c) $Zn(s)$ dissolves in water, enabling it to react rapidly with $I_2(s)$ and produce heat, subliming the I_2.
(d)☺ water dissolved a $ZnI_2(s)$ coating from the $Zn(s)$, exposing fresh $Zn(s)$ to $I_2(s)$ and enabling the *exothermic* reaction to rapidly produce heat and sublime excess $I_2(s)$.

47. Which statement about *transition* metal chemistry is **CORRECT**?

(a)☺ According to the crystal field theory, Δ_t is *less than* Δ_o because the ligands do not point directly at any metal orbital.
(b) Most transition elements are relatively soft and have low melting points.
(c) Most *3d* ions are good Lewis *bases*.
(d) *Galvanized* iron or steel has a coating of *lead* that protects the iron by making it the *anode* of an electrochemical cell.

48. Which statement about the demonstrations is **CORRECT**?

(a) A balloon filled only with $H_2(g)$ burns with a colorless flame.
(b) $Cl_2(g)$ oxidizes $KI(aq)$ to $(ICl_3)_2$, in the process also producing $HI(g)$, $ICl(\ell)$, and $I_2(s)$.
(c) Liquid O_2 adheres to the poles of a magnet because it is *diamagnetic*.
(d)☺ Silane, $SiH_4(g)$, spontaneously burns upon contact with $O_2(g)$ in the atmosphere to give H_2O and $SiO_2(s)$.

49. Identify the **net ionic** equation for the reaction,

$$Ba(NO_3)_2(aq) + K_2SO_4(aq) \rightarrow BaSO_4(s) + 2\ KNO_3(aq)$$

(a) $Ba(s) + SO_4^{2-}(aq) \rightarrow BaSO_4(s)$
(b) $Ba^{2+}(aq) + 2\ NO_3^{1-}(aq) + SO_4^{2-}(aq) \rightarrow BaSO_4(s) + 2\ NO_3^{1-}(aq)$
(c) $Ba^{2+}(aq) + 2\ NO_3^{1-}(aq) + 2\ K^{+}(aq) + SO_4^{2-}(aq) \rightarrow BaSO_4(s) + 2\ NO_3^{1-}(aq) + 2\ K^{+}(aq)$
(d)☺ $Ba^{2+}(aq) + SO_4^{2-}(aq) \rightarrow BaSO_4(s)$

50. Balance the equation in an **acidic** medium by using the smallest integral coefficients. Then, write on the answer sheet the number of **protons (H^+)** on the **LEFT** hand side of the balanced equation. (If no protons are on the left side, write "0"; for answers >9, use row 51 for the tens digit; row 50 for the units digit.)

$$Cr_2O_7^{2-}(aq) + HSO_3^{1-}(aq) \rightarrow Cr^{3+}(aq) + HSO_4^{1-}(aq)$$

The correct answer is **8**.

$Cr_2O_7^{2-} + 14\ H^+ + 6\ e \rightarrow 2\ Cr^{3+} + 7\ H_2O$
$3(H_2O + HSO_3^{1-} \rightarrow HSO_4^{1-} + 2\ H^+ + 2\ e)$