1. a, c, d, g, h
2. a. Usually a nucleophile (although it could also be an electrophile).
   b. O^- is nucleophilic (and phosphorus is electrophilic, having a partial positive charge)
   c. P_i has great resonance stabilization, better than R-O-PO_3^{2-}
3. (1) Reduction of charge repulsion,(2) increase in resonance stabilization, (3) ionization (deprotonation) of products, (4) more favored solvation of products; (5) sub-molar concentrations of adenylates and P_i in the cell; (6) higher ATP than ADP concentrations in the cell
4. Either $\Delta G'^\circ$ of hydrolysis (< -30.5 kJ/mol is high ptp), or whether the compound can transfer its phosphoryl to ADP (if yes, it has high ptp)
5. The cell has differing needs for redox reactions. Sometimes it needs an electron acceptor (oxidant), and sometimes an electron donor (reductant). NAD and NADP are kept at different concentrations of oxidized versus reduced forms to make one better at accepting electrons (NAD, because $[NAD^+]>[NADH]$) and one better at donating electrons (NADP, because $[NADPH]>[NADP^+]$). Also, different metabolites have different reduction potentials, which may require different electron acceptors (FAD has a higher reduction potential than NAD^+). Finally, some redox reactions involve two-electron transfers, and some involve one-electron transfers, so variety in redox currencies provides this flexibility (NAD and NADP can only participate in 2-electron transfers, in the form of hydride ions; FAD and FMN can participate in 1 or 2-electron transfers).
6. a & b are needed for the isomerization; d is likely for binding the phosphate
7. An isozyme is an enzyme that differs in protein sequence but catalyzes the same reaction.
8. False; they catalyze different reactions
9. Glucose. The γ phosphorus of ATP is more electrophilic than C6 of glucose.
10. In phosphoryl transfer reactions, the phosphoryl donor is the **electrophile** and the phosphoryl acceptor is the **nucleophile**.
11. c, maybe d. *explanation:* this enzyme uses acid-base catalysis, so ionizable aa's with pKa's not too far from physiologic (His, Cys, Glu/Asp, Tyr, Lys) are needed; also substrate is quite polar with negative charge on phosphate, so polar aa's (that can H-bond with substrate) are likely
    a. Arg, Ser, Met, Val – none easily participate in acid/base chemistry; too nonpolar
    b. Phe, Val, Ile, Thr – none easily participate in acid/base chemistry; too nonpolar
    c. Ser, Cys, His, Gln – *good mix of acid/base capable and polar*
    d. Tyr, Thr, Trp, His – some acid/base capability, but with big bulky rings (may be able to stack with sugar ring, may not; may be too bulky and take up space in active site)
    e. Gly, Ala, Cys, Pro – limited acid/base chemistry, somewhat nonpolar
12. a, b, c, d
13. Many intermediates of glycolysis have lots of negative charge, and this charge must be directed away from electrophilic atoms to promote nucleophilic attack (or electron movements). Positively-charged metal ions help offset/direct this charge.
14. Phosphoglycerate kinase and pyruvate kinase. They are both kinases, and the reactions both involve transfer of a phosphoryl group from a metabolic intermediate to ADP, to yield ATP.