C483 Exam 1
Summer 2017

Name Key Seat Number ________

Student ID ______________________ AI ______________________

The last page of this exam contains pKa values and other information you might find useful.
This exam contains 110 points. The highest score you may earn on this exam is 100 points.

1 ________/20pts

2. ________/10pts

3. ________/20pts

4. ________/10pts

5. ________/10pts

6. ________/10pts

7. ________/10pts

8. ________/10pts

9. ________/10pts

Total:

Regrading: All requests for regrades must be submitted in writing within 48 hours of the return of the exam. You must explicitly state what has been misgraded and why it is an error. The entire exam will be regraded, which could result in points being added or deducted overall.

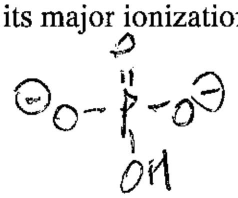
Section 1: Reading guides (50 points)

1. 20 pts. Fill in the blanks (2 points each.)

A. Polysaccarides are carbohydrate polymers with residues held together through linkages called glycosidic bonds.

B. Molecules such as detergents that contain both hydrophilic and hydrophobic portions are said to be amphipathic.

C. Draw phosphoric acid in its major ionization state at pH 8.



D. Two differences between a nucleotide and a deoxynucleoside are:

deoxynucleoside (1) No 2' -OH
(2) No phosphateester

E. The interior of a globular protein often contains regular (regular/irregular) secondary structures in order to maintain H-bonds between backbone peptides.

F. Size exclusion (gel filtration) chromatography separates proteins based on size, with larger (smaller/larger) proteins eluting from the column first.

G. Myoglobin does not have a central cavity like hemoglobin because myoglobin is monomeric. (single subunit)

H. Keratin's structure can be described as coiled-coil, while collagen's structure is triple helical.

I. If the lock + key model of substrate/enzyme binding were true, the enzyme would slow the reaction.

J. Many enzymes, including proteases, contain a specificity pocket which allows an enzyme to speed the reacton of one substrate more than it speeds the reaction of another.

2. 10 pts. True or false (1 points each)

A. False An mRNA transcribed from a DBA template strand with sequence '5-GCTA-3' would have the sequence 5'-CGAU-3'.

B. False Any process that has a negative change in enthalpy will be spontaneous.

C. True Molecules such as proteins are unable to diffuse across a lipid bilayer.

D. True The pH of an aqueous solution of 1×10^{-3} M HCl has a pH of 3.

E. False If a denatured DNA double helix is allowed to cool too slowly, it will often improperly base pair rather than correctly renaturing.

F. False ADP contains one phosphodiester linkage.

G. True The amino acid F is more nonpolar than the amino acid Y.

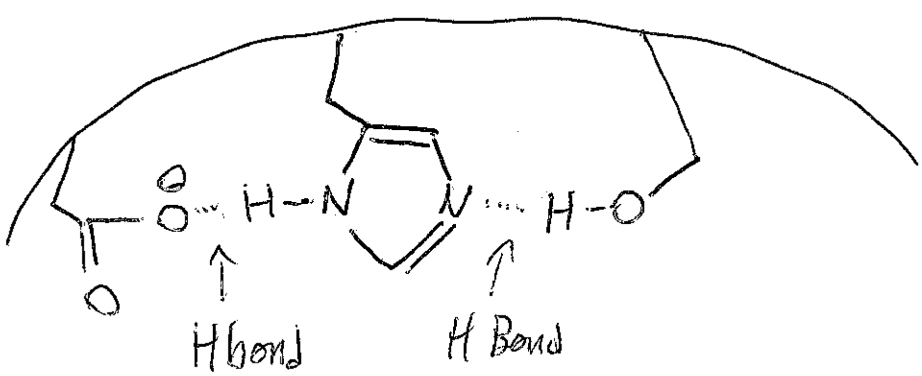
H. True The hydrophobic oxygen binding pocket in hemoglobin helps to minimize oxidation of the heme group when oxygen binds.

I. True Some coenzymes are cosubstrates and some are not.

J. True A catalyst can lower the activation energy of a reaction either by relatively stabilizing the transition state or destabilizing the starting materials (or both.)

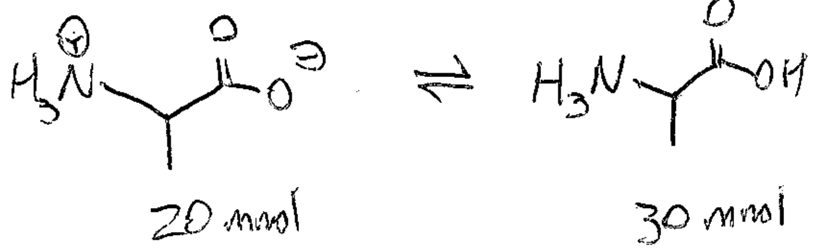
3. 20 pts. Short answer (5 points each)

A. Draw the sidechains of the catalytic triad of chymotrypsin and indicate the intermolecular interactions between them:



+2 Hbonds
+1 each
S.dechain

B. To an aqueous solution containing 50 mmol of zwitterionic alanine, 30 mmol of HCl was added. What is the final pH of this solution?

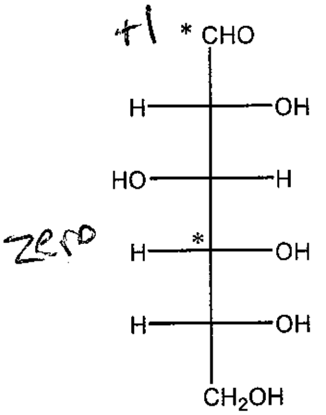


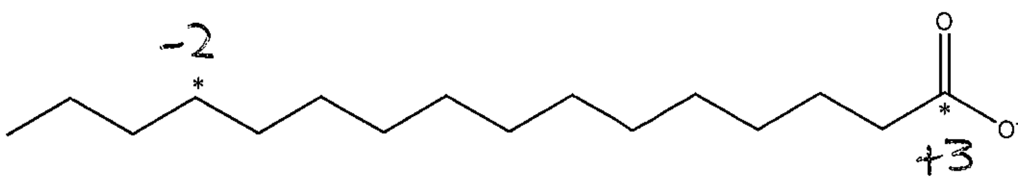
$$pH = pK_a + \log \frac{A^-}{HA}$$

$$= 3.1 + \log \frac{20}{30}$$

$$= \boxed{2.9}$$

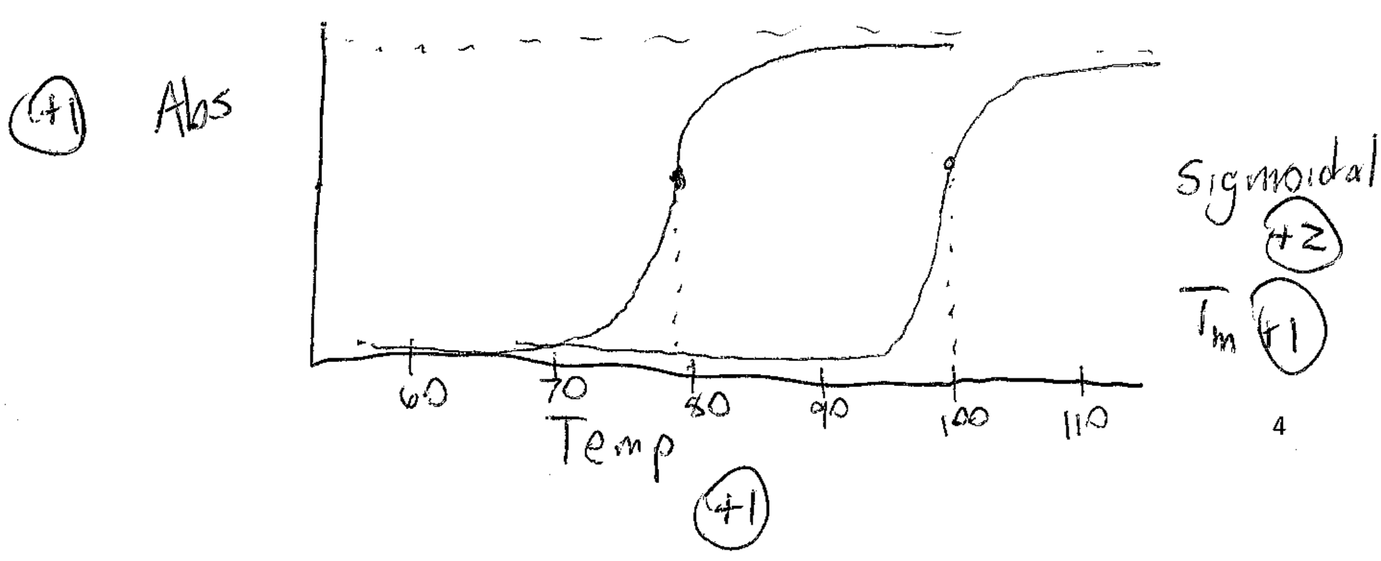
C. Below are structures for glucose and palmitate. Indicate the oxidation state of each of the indicated atoms. On a per-carbon basis, which would make more free energy available for metabolic reactions?





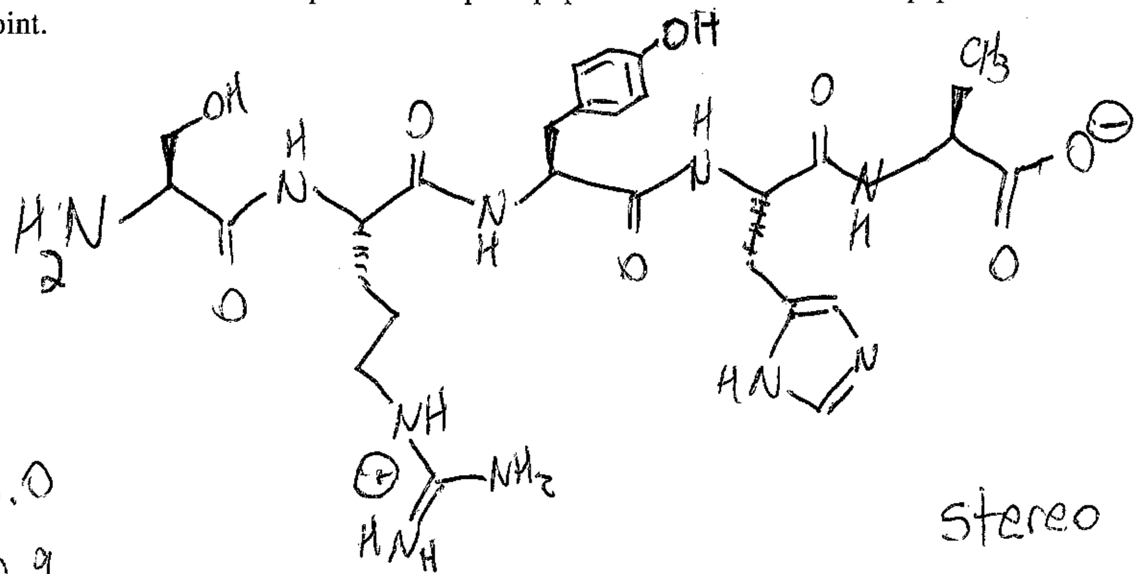
(+1) palmitate - more reduced

D. Draw DNA melting curves for *Dictyostelium discoideum* (T_m = 79.5°C) and *Streptomyces albus* (T_m = 100.5 °C).



Section 2: Problems (10 points each)

4. What is the isoelectric point of the pentapeptide SRYHA? Draw this peptide at its isoelectric point.



↑ 8.0

↓ 10.9

pI = 9.5 (+2)

stereo (+1)

backbone (+2)

ionization (+2)

Sidechains (+3)

5. Fill in the table below with the relative strengths of these intermolecular forces in DNA, and use it to write a short explanation of the origin of the stability of the double helix form of double stranded DNA.

	DNA double helix Native State	Denatured DNA
Pi Stacking	significant stabilizing	little
Hydrophobic Effect	significant stabilizing	little
H-bonding	significant ⟷	significant
Ionic interactions	similar ⟷	similar
Entropy of strands	little	significant

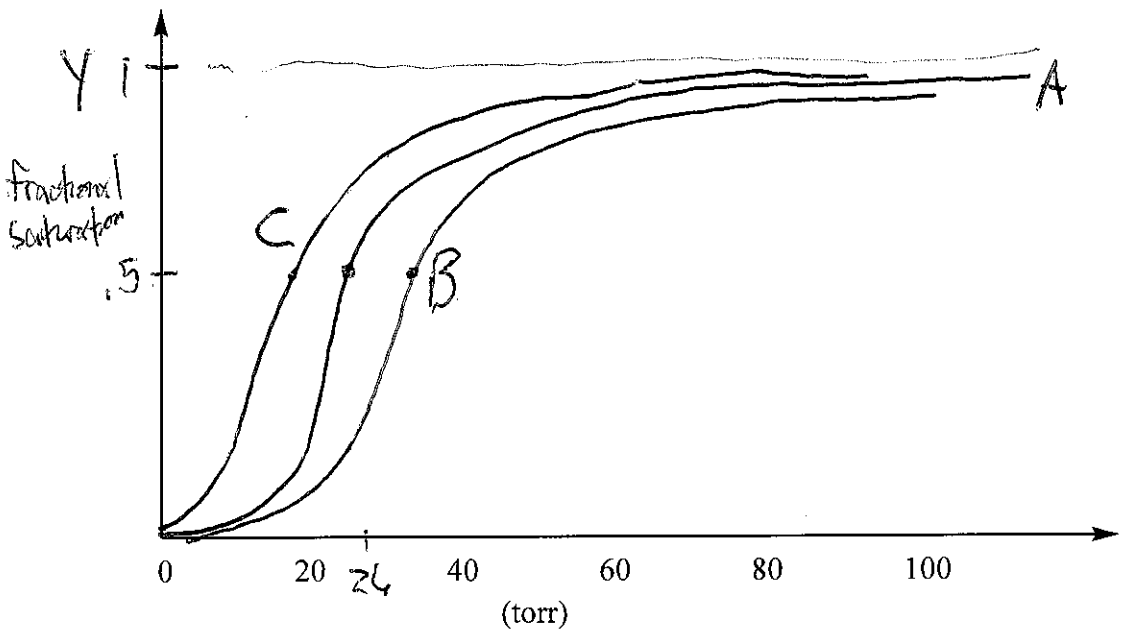
The major contributors for double helix stablization are Pi stacking and hydrophobic effect when the bases are stacked rather than open to water. H-bonding is not a significant stablizer because the bases form strong H-bonds with water when denatured.

6. Draw oxygen binding curves for the following three hemoglobin molecules. Label each curve A, B, or C. Label the axes of the graph.

A. Typical hemoglobin bound to 2,3-bPG, which has a P_{50} = 26 torr, blood pH =7.4, and is almost fully saturated in the lungs at 100 torr O_2.

B. Typical hemoglobin in tissue where the blood pH has dropped to 7.2.

C. Mutant hemoglobin that binds 2,3-bPG very loosely, destabilizing the Hb T-state.



(+2) All sigmoidal

(+2) (A) has ½ max at 26 torr

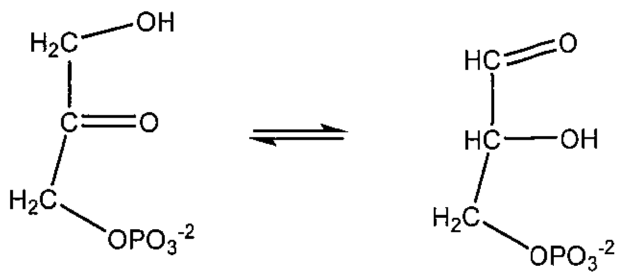
(+2) (B) has ½ max at ↑ 26 torr

(+2) (C) has ½ max at ↓ 26 torr

(+1) near saturation at 100

(+1) label axes

7. Triose phosphate isomerase catalyzes the isomerization of dihydroxyacetone phosphate to glyceraldehyde-3-phosphate.



The enzyme has an active site glutamate that acts as a general base in the first step of the reaction and an active site histidine that acts as a general acid in the first step. Draw a stepwise mechanism for this isomerization.

See notes

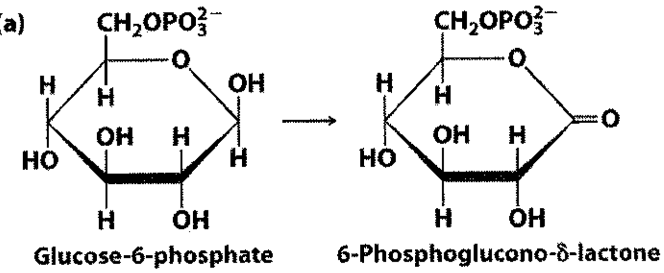
(+2) correct general acid/base

(+4) enediol intermediate

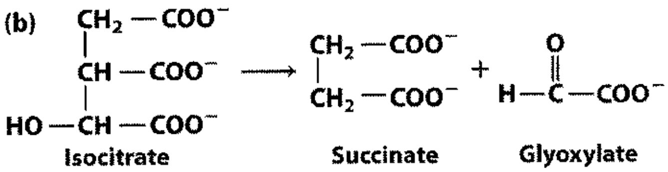
(+4) Arrows

+1 each

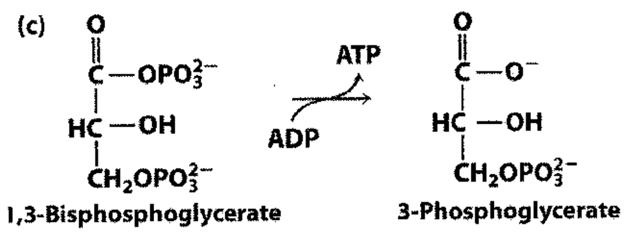
8. Label each of the following enzymes or enzymatically-catalyzed reactions according to the class of enzyme to which they belong: oxidoreductase, transferase, hydrolase, lyase, isomerase, or ligase.

(a) 

Oxidoreductase

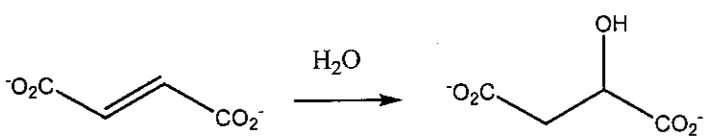
(b) 

lyase

(c) 

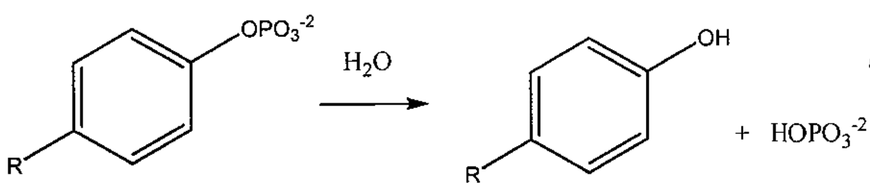
transferase

D.



lyase

E.



hydrolase

F. Chymotrypsin hydrolase

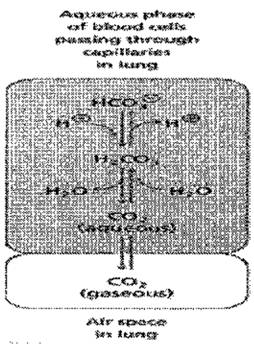
G. Pyruvate kinase transferase

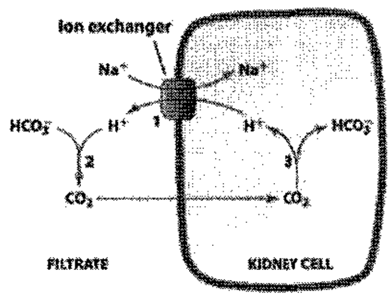
H. Alanine racemase isomerase

I. Malate dehydrogenase oxidoreductase

J. Alanine aminotransferase transferase

Section 3: Case study (10pts) Metabolic acidosis and respiratory acidosis are the two leading causes of acidosis in humans. Metabolic acidosis is caused when the body makes too much acid and the kidneys do not do a good job of removing enough acid. Poor CO_2 exchange can lead to respiratory acidosis. The general mechanisms by which lungs and kidneys regulate bicarbonate levels are given below.





A. Respiratory Acidosis: Describe how accumulation of CO_2 in the lungs will cause a change in blood pH. CO_2 accumulation in lungs leads to higher $[CO_2]$ in blood,

+4 which shifts this equilibrium by Le Chatelier:

$$CO_2 + H_2O \rightarrow H_2CO_3 \rightarrow H^+ + HCO_3^-$$

This leads to a decrease in blood pH.

B. Metabolic Acidosis: In the case of metabolic acidosis the body tries to compensate for change in pH by altering the function of kidneys. Would the kidneys increase excretion or retention of the following ions in the case of metabolic acidosis? Explain.

+2 $H_2PO_4^-$ $H_2PO_4^- \rightleftharpoons HPO_4^{2-} + H^+$ (pKa 6.8) ← Excrete! Lowers $[H^+]$

+2 NH_4^+ $NH_4^+ \rightleftharpoons NH_3 + H^+$ ← Excrete!

+2 HCO_3^- $H_2CO_3 \rightleftharpoons HCO_3^- + H^+$ ← Retain!

Data Tables

Amino acid pKa values

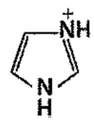
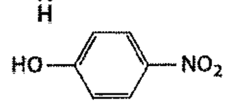
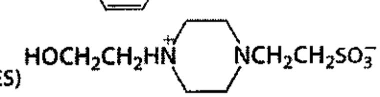
C-terminal	3.1
N-terminal	8.0
Aspartate, glutamate	4.1
Histidine	6.1
Cysteine	8.3
Tyrosine	10.9
Lysine	10.8
Arginine	12.5

[TABLE 3-3] The Standard Genetic Code[a]

First Position (5′ end)	Second Position U	Second Position C	Second Position A	Second Position G	Third Position (3′end)
U	UUU Phe	UCU Ser	UAU Tyr	UGU Cys	U
	UUC Phe	UCC Ser	UAC Tyr	UGC Cys	C
	UUA Leu	UCA Ser	UAA Stop	UGA Stop	A
	UUG Leu	UCG Ser	UAG Stop	UGG Trp	G
C	CUU Leu	CCU Pro	CAU His	CGU Arg	U
	CUC Leu	CCC Pro	CAC His	CGC Arg	C
	CUA Leu	CCA Pro	CAA Gln	CGA Arg	A
	CUG Leu	CCG Pro	CAG Gln	CGG Arg	G
A	AUU Ile	ACU Thr	AAU Asn	AGU Ser	U
	AUC Ile	ACC Thr	AAC Asn	AGC Ser	C
	AUA Ile	ACA Thr	AAA Lys	AGA Arg	A
	AUG Met	ACG Thr	AAG Lys	AGG Arg	G
G	GUU Val	GCU Ala	GAU Asp	GGU Gly	U
	GUC Val	GCC Ala	GAC Asp	GGC Gly	C
	GUA Val	GCA Ala	GAA Glu	GGA Gly	A
	GUG Val	GCG Ala	GAG Glu	GGG Gly	G

[a]The 20 amino acids are abbreviated: Ala, alanine; Arg, arginine; Asn, asparagine; Asp, aspartate; Cys, cysteine; Gly, glycine; Gln, glutamine; Glu, glutamate; His, histidine; Ile, isoleucine; Leu, leucine; Lys, lysine; Met, methionine; Phe, phenylalanine; Pro, proline; Ser, serine; Thr, threonine; Trp, tryptophan; Tyr, tyrosine; and Val, valine.

[TABLE 2.4] *pK* Values of Some Acids

Name	Formula[a]	p*K*
Trifluoroacetic acid	CF_3COOH	0.18
Phosphoric acid	H_3PO_4	2.15[b]
Formic acid	HCOOH	3.75
Succinic acid	$HOOCCH_2CH_2COOH$	4.21[b]
Acetic acid	CH_3COOH	4.76
Succinate	$HOOCCH_2CH_2COO^-$	5.64[c]
Thiophenol	C_6H_5SH	6.60
Phosphate	$H_2PO_4^-$	6.82[c]
N-(2-acetamido)-2-aminoethanesulfonic acid (ACES)	$H_2NCOCH_2\overset{+}{N}H_2CH_2CH_2SO_3^-$	6.90
Imidazole		7.00
p-Nitrophenol		7.24
N-2-hydroxyethylpiperazine-N′-2-ethanesulfonic acid (HEPES)		7.55
Glycinamide	$^+H_3NCH_2CONH_2$	8.20
Tris(hydroxymethyl)-aminomethane (Tris)	$(HOCH_2)_3C\overset{+}{N}H_3$	8.30
Boric acid	H_3BO_3	9.24
Ammonium ion	NH_4^+ 9.25	
Phenol	C_6H_5OH	9.90
Methylammonium ion	$CH_3NH_3^+$	10.60
Phosphate	HPO_4^{2-}	12.38[d]

[a]The acidic hydrogen is highlighted in red; [b]pK_1; [c]pK_2; [d]pK_3.