Biology 638 – Biochemistry II
Final Exam

You cannot use anything other than your brain, pencils, and eraser in this exam.

Using the following values, answer questions in this exam.

$ATP + H_2O \leftrightarrow ADP + P_i$	$\Delta G°' = -30$ kJ/mol
$G6P + H_2O \leftrightarrow Glucose + P_i$	$\Delta G°' = -14$ kJ/mol
$½O_2 + 2H^+ + 2e^- \leftrightarrow H_2O$	$\Delta E°' = 0.75$ V
$NAD^+ + H^+ + 2e^- \leftrightarrow NADH$	$\Delta E°' = -0.3$ V

$R = 10.0$ J·mol^{-1}· K^{-1} $F = 100.0$ kJ·V^{-1} T = 300 K $ln(x) = 2log(x)$

Select the closest answer in all calculations.

1. Assume that the concentrations of ATP, ADP, P_i ,H^+ in the matrix of mitochondrion are constant and are 0.1 mM, 0.01 mM, 0.1 mM, and 10^{-8} M, respectively. The electropotential between the inside and outside is 300 mV (inside is negative). The pH gradient and electropotential energies can be used to synthesize ATP from ADP and P_i. What is the pH of outside (intermembrane space) of mitochondrion to maintain the same concentrations of ATP, ADP, P_i in the matrix?

a. 3 b. 4 c. 5 d. 6 e. 7

2. O_2 is reduced by NADH to H_2O in a mitochondrion. If 60% of the all oxidation energy produced in the reaction is utilized to synthesize ATP from ADP + P_i, how many ATP would be synthesized from **ten** H_2O formation from O_2 and NADH?

a. 38 b. 40 c. 42 d. 45 e. 50

3 Assume that G6P is completely oxidized through the pentose phosphate pathway. The produced NADPH is converted to NADH with 66.7% energy efficiency (i.e., 3NADPH = 2NADH). The produced NADH is used to produce ATP from ADP and P_i by oxidative phosphorylation. The energy efficiency of the oxidative phosphorylation process is 75%. _____ mole of ATP is produced from one mole of G6P oxidation to CO_2.

a. 20 b. 25 c. 30 d. 35 e. 40

4. G6P is synthesized in a biological cell from glucose and ATP using hexokinase. The initial concentrations of glucose, ATP, ADP, and G6P are 0.5 mM, 0.2mM, 0.01 mM, and 0.1 mM, respectively. What is the free energy change (ΔG) kJ/mol in this synthesis?

a. -10 b. -15 c. -20 d. -30 e. -40

5. Assume that one acetyl-CoA is synthesized from CO_2, H_2O, and CoA using 20 ATP's. The produced acetyl-CoA molecules are utilized to synthesize glucose through the glyoxylate pathway and gluconeogenesis. How many ATP molecules are required to make **Ten** glucose molecules from CO_2 and H_2O? Assume that NADH, $FADH_2$, and GTP are equivalent to three, two and one ATP, respectively.

a. 550 b. 600 c. 650 d. 700 e. 750

6. Assume that a C_3 plant can produce **ten** G6P using either the cyclic or non-cyclic pathways. Assume that one NADPH is produced from three ATP, but ATP is not produced from NADPH. How many photons are necessary for the most efficient synthesis?

a. 400 b. 450 c. 500 d. 550 e. 600

7. (cis $\Delta^{9,12,15}$ C_{24}) fatty acid is completely oxidized to CO_2 by β-oxidation and the citric acid cycle, and the produced CO_2 is converted to glucose using the enzymes in the dark reaction. How many moles of ATP are consumed from the fatty acid to glucose conversion? Assume that acetyl-CoA, propionyl-CoA, NADH, NADPH, and $FADH_2$ are equivalent to 12ATP, 20ATP, 3ATP, 3ATP and 2ATP, respectively.

a. 10 b. 15 c. 20 d. 25 e. 30

8. Complete oxidation of **two** acetyl group in the citric acid cycle produces ____ pairs of electrons.

a. 3 b. 4 c. 8 d. 12 e. 16

9. Select the statement that is **not** correct. Assume that the ([ADP]+[AMP])/[ATP] ratio in liver cells is 10^{-5}, and this person is relatively healthy.
a. This person has large amount glycogen in his liver.
b. This person's activity of FBPase-2 in liver is high.
c. This person's pancreas secrets occasionally insulin.
d. This person's PFK-2 activity in liver is low.
e. None of the above.

10. Caffeine inhibits _____.
a. hydrolysis of cAMP
b. GTP hydrolysis on $G_{i\alpha}$
c. separation of protein kinase A ($R_2C_2 \rightarrow R_2 + C_2$)
d. GTP hydrolysis on $G_{s\alpha}$
e. None of the above.

11. Parkinson's disease is caused by deficiency of the enzyme that produces _____.
a. L-DOPA
b. serotonin
c. dopamine
d. GABA
e. None of the above

12. HMG-CoA in cytosol of liver cells is converted to _____.
a. ketone bodies
b. mevalonate
c. malonyl-CoA
d. propionyl-CoA
e. None of the above.

13. Vitamin B_{12} _____.
a. is a water insoluble vitamin
b. is involved in deamination reaction
c. contains a heme
d. is involved in odd carbon fatty acid metabolism
e. None of the above**.**

14. Select the statement that is **not** correct.
a. Epinephrine is synthesized from Tyrosine.
b. Serine is synthesized from 3GP.
c. S-adenosylhomocysteine is hydrolyzed to adenine and homocysteine.
d. Pro-insulin is a single polypeptide.
e. GSH is regenerated from GSSH using the NADPH reduction energy.

15. Cholera toxin inhibits _____.
a. ADP-ribosylation on a His residue located in the GTP binding site of $G_{s\alpha}$
b. GTP hydrolysis on $G_{i\alpha}$
c. cAMP hydrolysis to AMP
d. $G_{i\alpha}$ from exchanging its bound GDP for GTP
e. None of the above.

16. The methyl group of SAM comes from _____ in the biosynthesis.
a. N^5-Formyl-THF
b. N^5,N^{10}-methylene-THF
c. N^5-Methyl-THF
d. N^{10}-Formyl-THF
e. None of the above.

17. Fructose has different metabolic pathways in muscle and liver because _____
a. fructose in muscle is converted to glucose but not in liver
b. the K_M values of hexokinase and glucokinase are very different
c. fructose in muscle is converted to GAP but not in liver
d. liver does not have hexokinase
e. None of the above.

18. Select the statement that is **not** true. The PLP bound enzymes involve in ____.
a. transamination reactions.
b. phosphorylation
c. decarboxylation
d. isomerization
e. None of the above.

19. Enzymes whose catalytic activities are controlled by an allosteric regulation _____.
a. must be oligomeric
b. must have an ATP binding site
c. must have a phosphorylation site
d. must have an AMP binding site
e. None of the above or all of the above.

20. 5-FU is an important anti-cancer drug. This drug _____.
a. is converted to 5-FUTP which forms an unbreakable ternary covalent complex with thymidylate reductase.
b. is converted to 5-FdUMP which forms an unbreakable ternary covalent complex with thymidylate synthase.
c. is converted to 5-FdUTP which is incorporated into DNA and inhibits the RNA synthesis
d. is converted to 5-FdUMP which forms an unbreakable ternary covalent complex with dihydrofolate reductase.
e. None of the above.

Assume the following four persons eat meat (protein and fat), and take a multi-vitamin tablet containing multiple-minerals everyday, and suddenly, they developed the following genetic problem:

Person A lost pyruvate carboxylase in his liver.
Person B lost glucose-6-phosphate dehydrogenase in his liver.
Person C lost fructose-1,6-bisphosphatase (FBPase) in his liver.
Person D lost acetyl-CoA carboxylase in his liver.

Answer the following two questions.

21. Whose urine become smell sweet after one week?

a. A b. B c. C d. D e. None of them

22. How many person(s) would survive for one month under a normal condition?

a. 0 b. 1 c. 2 d. 3 e. 4

23. 4Mn-4O cluster in OEC involves in _____.

a. abstraction of electrons from water
b. pumping of proton from stroma to thylakoid
c. conversion of PQ to PQH_2
d. phosphorylation of LHC
e. None of the above.

24. Physical exercise is an important for healthy life. For example, an exercise reduces the cholesterol level in blood by _____.

a. phosphorylation of acetyl-CoA carboxylase
b. phosphorylation of HMG-CoA lyase
c. phosphorylation of HMG-CoA reductase
d. phosphorylation of hormone sensitive triacylglycerol lipase
e. None of the above.

25. Select the statement that is **not** true. The carbon skeleton of a ceramide originates from ___.

a. serine b. palmitate
c. fatty acid d. glycerol
e. None of the above.

26. A scientist cloned the genes of all glyoxylate pathway enzymes in adipose cells of green chameleon. Select the correct statement.

a. This animal can synthesize glucose from both amino acids and fats.
b. This animal cannot synthesize glucose from either amino acids or fats.
c. This animal can synthesize glucose from amino acids, but not from fats.
d. This animal can synthesize glucose from fats.
e. None of the above.

27. If the [NAD^+]/[NADH] and [$NADP^+$]/[NADPH] ratios in liver cells were suddenly equal to 1.0, then what would happen in next ? Select the statement that is **not** correct.
a. Activity of the citric acid cycle would be slow-down.
b. The concentrations of free GSH and GSSG would be decreased and increased, respectively.
c. Glycogen synthesis would be increased
d. Insulin would be secreted from pancreas
e. None of the above.

28. Assume that you are a marathon runner and have an important race (42.195 km race) in tomorrow. Which food would you eat to win the tomorrow's race?
a. Big spaghetti (mainly carbohydrate)
b. Small bread with a lot of butter (mainly fat and a little carbohydrate)
c. Big KC steak (mainly protein and fat)
d. Big turkey barest (mainly protein)
e. None of the above.

29. Transketolase converts S7P and GAP to _____.
a. F6P and GAP
b. Xu5P and R5P
c. E4P and F6P
d. R5P and F6P
e. None of the above.

30. Some of inducible transcription factors can be activated by binding of _____.
a. cortisol
b. progesterone
c. testesterone
d. estradiol
e. All of the above

31. A diagnostic criterion for myocardial infarction is the presence of H-type lactate dehydrogenase (H-LDH) in the blood because ____.
a. heart muscle cells are broken due to lack of ATP
b. heart muscle cells produces ATP from Ketone bodies instead of glucose and unnecessary H-LDH is released into blood stream
c. H-LDH is overproduced in heart muscle cells to generate ATP by through anaerobic glycolysis and some of H-LDH is released into blood stream
d. H-LDH is overproduced in heart muscle cells to generate ATP by through aerobic glycolysis and some of H-LDH is released into blood stream
e. None of the above.

32. There are several different types of glucose transporters. An active transporter is seen on _____.
a. erythrocytes
b. muscle cells
c. liver cells
d. brush-border cells
e. None of the above.

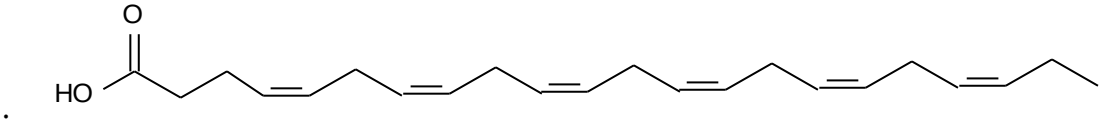
33. In the glycogen break down and synthesis, phosphorylation plays an important role in the regulation. ___ is regulated by both cAMP-dependent and -independent phosphorylations.
a. Glycogen phosphorylase
b. Phosphoprotein phosphatase-1
c. Glycogen synthase
d. Phosphoprotein phosphatase inhibitor-1
e. None of the above.

34. Pyruvate in cytosol is transported to mitochondrion by _____.
a. pyruvate-aspatate shuttle
b. pyruvate-Na^+ symport
c. pyruvate-Ca^{2+} antiport.
d. pyruvate-H^+ symport
e. None of the above.

35. Select the statement that is **not** correct.
a. Antisense strands in Pribnow boxes have AT-rich sequences.
b. Rho-factor binds after a GC rich palindromic sequence and to terminate some RNA synthesis
c. A function of sigma-70 in prokaryotic RNA polymerase is to recognize the initiation site.
d. Rho-factor binds to sense strand.
e. DNA gyrase unwinds double stranded DNA.

36. A primary transcript of mRNA from a constitutive gene has _____.
a. a GC box sequence near the 3'-end
b. a TATA box sequence near the 5'-end
c. a TATA box sequence near the 3'-end
d. a GC box sequence near the 5'-end
e. None of the above

37. An omega-3 oil (DHA) shown below is not synthesized in mammalian cells. DHA can be synthesized in mammalian cells from a unsaturated C_{18} fatty acyl-CoA. This unsaturated C_{18} fatty acyl-CoA is produced from the saturated C_{18}-fatty acyl-CoA by adding double bonds using <u>all available plant desaturases</u>. In order to produce DHA in mammalian cells from the unsaturated C_{18} fatty acyl-CoA, _____ is first utilized to add a double bond in a mammalian cell.



a. Δ^4-fatty acyl-CoA desaturase
b. Δ^5-fatty acyl-CoA desaturase
c. Δ^6-fatty acyl-CoA desaturase
d. Δ^9-fatty acyl-CoA desaturase
e. None of the above or no unique answer.

38. Assume that a bio-cell was consuming O_2 before adding oligomycin B. Adding ____ in the bio-cell would restart the O_2 consumption.
a. vitamin C and TMPD
b. β-hydroxybutyrate
c. succinate
d. 2,4-dinitrophenol
e. None of the above

39. The self splicing reaction of eukaryotic pre-mRNA begins with the attack of _____.
a. a 2'-OH in the intron on a phosphodiester bond at the 5'-splice site
b. a 3'-OH in the exon on a phosphodiester bond at the 3'-splice site
c. a 3'-OH in the intron on a phosphodiester bond at the 3'-splice site
d. a 2'-OH in the exon on a phosphodiester bond at the 5'-splice site
e. None of the above.

40. Which process produces the second CO_2 from acetyl-CoA in the citric acid cycle?
a. Oxidation of isocitrate
b. Oxidation of malate
c. Oxidation of α-ketoglutarate
d. Oxidation of succinyl-CoA
e. None of he above.

41. Select the statement that is **not** true. If glucokinase in liver is suddenly changed to hexokinase, what will happen?
a. The insulin concentration in blood will be decreased.
b. The F2,6P concentration in liver will be decreased.
c. The glucagon concentration in blood will be increased.
d. The glucose concentration in blood will be decreased.
e. None of the above.

42. If DNA were synthesized 3' to 5' instead of 5' to 3' direction, the chain elongation would stop after the editing process because _____.
a. dNTPs do not have a triphosphate (-PPP) on 3'-O.
b. dNTPs do not have a triphosphate (-PPP) on 5'-O
c. the 3'-end of DNA does not have a triphosphate (-PPP)
d. the 5'-end of DNA does not have a triphosphate (-PPP)
e. None of the above.

43. Glycogen is a ploy-glucose with a lot of branches. Assume that a glycogen is completely digested (i.e., all of them are monosaccharides) in a test tube by glycogen phosphorylase and debranching enzyme. The concentrations of _____ in the test tube should give the average number of branches per glucose.
a. G1P and G6P
b. maltose and glucose
c. glucose and G1P
d. glucose and G6P
e. None of the above.

44. Select the statement that is **not** correct. The cGMP level in smooth heart muscle cells can be elevated by _____.

a. activating protein kinase A
b. activating NO synthetase
c. taking nitroglycerin
d. increasing IP_3 synthesis
e. None of the above.

45. An enzyme catalyzes: A + B + ATP $\rightarrow$ C + ADP + P_i. The general name of this enzyme is _____.

a. C kinase
b. C synthase
c. C synthetase
d. A phosphorylase
e. None of the above

46. A person's urine becomes red color. This person might have a degradation problem from _____.

a. pyruvate to Phe
b. Tyr to Phe
c. Gly to Tyr
d. Phe to Tyr
e. None of the above

47. Incorporation of U in DNA might alter a somatic cell to a cancer cell because _____.

a. U can become T
b. U can form a stable UG base pair
c. uracil-N-glycosylase removes the incorporated U and produces unpaired DNA
d. the incorporated U and naturally converted U are indistinguishable.
e. None of the above.

48. The heme level regulates the globin synthesis because _____.

a. heme inhibits heme-controlled repressor
b. heme stimulates phosphorylation of eIF-2B
c. heme stimulates the tight complex formation between eIF-2 and eIF-2B
d. heme inhibits the posttranscriptional modification of pro-heme-controlled repressor
e. None of the above.

49. Actinomycin has a strong anti-cancer activity because _____.

a. it binds to a single stranded DNA and inhibits both DNA and RNA polymerases
b. it binds to a double stranded DNA and inhibits the RNA synthesis
c. it binds to RNA polymerase and inhibits the RNA synthesis
d. it binds to a double stranded RNA and inhibits the RNA synthesis
e. None of the above

50. A section of *E. coli* DNA strand has a characteristic sequence:

5'-$(A)_7(CG)_{10}(A)_5(CG)_{10}(AGA)_2$-3'.

This suggests that _____.

a. the characteristic sequence is most likely a termination site of antisense strand
b. the characteristic sequence is most likely a promoter site of sense strand
c. the characteristic sequence is most likely a termination site of sense strand
d. the characteristic sequence is most likely a telomere appended by telomerase
e. None of the above.

Biol 638, Final Exam (Code-1)

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Final Exam

You cannot use anything other than your brain, pencils, and eraser in this exam.

Using the following values, answer questions in this exam.

$ATP + H_2O \leftrightarrow ADP + P_i$	$\Delta G^{\circ\prime} = -30$ kJ/mol
$G6P + H_2O \leftrightarrow Glucose + P_i$	$\Delta G^{\circ\prime} = -14$ kJ/mol
$½O_2 + 2H^+ + 2e^- \leftrightarrow H_2O$	$\Delta E^{\circ\prime} = 0.75$ V
$NAD^+ + H^+ + 2e^- \leftrightarrow NADH$	$\Delta E^{\circ\prime} = -0.3$ V

$R = 10.0\ J \cdot mol^{-1} \cdot K^{-1}$ $F = 100.0\ kJ \cdot V^{-1}$ $T = 300$ K $ln(x) = 2log(x)$

Select the closest answer in all calculations.

1. Assume that the concentrations of ATP, ADP, P_i, H^+ in the matrix of mitochondrion are constant and are 0.1 mM, 0.01 mM, 0.1 mM, and 10^{-8} mM, respectively. The electropotential between the inside and outside is 300 mV (inside is negative). The pH gradient and electropotential energies can be used to synthesize ATP from ADP and P_i. What is the pH of outside (intermembrane space) of mitochondrion to maintain the same concentrations of ATP, ADP, P_i in the matrix?

a. 3 b. 4 c. 5 d. 6 e. 7

ATP hydrolysis energy

$$\Delta G = \Delta G^\circ + RT \ln \frac{[ADP][P_i]}{[ATP][H_2O]} = -30k + 10 \times 300 \times 2 \times \log \frac{0.01 \times 10^{-3} \times 0.1 \times 10^{-3}}{0.1 \times 10^{-3} \times 1}$$

$$= -30k + 10 \times 300 \times 2 \times (-5) = -60k\ J$$

pH gradient and electropotential energies

$$\Delta G = RT \ln \frac{[H^+]_{in}}{[H^+]_{out}} + nF\Delta E = 10 \times 300 \times 2 \times \log \frac{10^{-8}}{10^{-x}} + 1 \times 100k \times -0.3$$

$$= 6k(x-8) - 30k$$

$$-60k = 6k(x-8) - 30k$$

$$-30 = 6x - 48$$

$$6x = 18$$

$$x = 3$$

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2. O_2 is reduced by NADH to H_2O in a mitochondrion. If 60% of the all oxidation energy produced in the reaction is utilized to synthesize ATP from ADP + P_i, how many ATP would be synthesized from **ten** H_2O formation from O_2 and NADH?

a. 38 b. 40 c. 42 d. 45 e. 50

$\frac{1}{2}O_2 + NADH \longrightarrow H_2O + NAD^+ \quad \Delta E = 1.05V \quad (0.75 - (-0.3))$

$\Delta E = -2 \times 100k \times 1.05V \times 0.6 = -210 \times 0.6\ (60\%)\ kJ.$

10 H_2O, So 10×

$$\frac{210k \times 0.6 \times 10}{-30k} = 42$$

3 Assume that G6P is completely oxidized through the pentose phosphate pathway. The produced NADPH is converted to NADH with 66.7% energy efficiency (i.e., 3NADPH = 2NADH). The produced NADH is used to produce ATP from ADP and P_i by oxidative phosphorylation. The energy efficiency of the oxidative phosphorylation process is 75%. _____ mole of ATP is produced from one mole of G6P oxidation to CO_2.

a. 20 b. 25 c. 30 d. 35 e. 40

$G6P \longrightarrow 6CO_2 + 12\,NADPH\ (8\,NADH)$ ← 8 NADH are produced

$NADH + \frac{1}{2}O_2 \longrightarrow NAD^+ + H_2O \quad \Delta E = 1.05V$

$\Delta G = -2 \times 100k \times 1.05V = -210\,kJ$

$$\frac{8 \times 210kJ \times 0.75}{-30kJ} = \frac{56 \times 3}{4} = 42$$

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4. G6P is synthesized in a biological cell from glucose and ATP using hexokinase. The initial concentrations of glucose, ATP, ADP, and G6P are 0.5 mM, 0.2mM, 0.01 mM, and 0.1 mM, respectively. What is the free energy change (ΔG) kJ/mol in this synthesis?

a. -10 b. -15 c. -20 (d.) -30 e. -40

Glucose + ATP ⟶ G6P + ADP $\quad \Delta G^\circ = -30 + 14 = -16\,kJ$

$$\Delta G = \Delta G^\circ + RT \ln \frac{[G6P][ADP]}{[Glucose][ATP]} = -16k + 10 \times 300 \times 2 \times \log \frac{0.01mM \times 0.1mM}{0.5mM \times 0.2mM}$$

$$= -16k + 10 \times 300 \times 2 \times -2$$

$$= -16k - 12k = -28\,kJ$$

5. Assume that one acetyl-CoA is synthesized from CO_2, H_2O, and CoA using 20 ATP's. The produced acetyl-CoA molecules are utilized to synthesize glucose through the glyoxylate pathway and gluconeogenesis. How many ATP molecules are required to make **Ten** glucose molecules from CO_2 and H_2O? Assume that NADH, $FADH_2$, and GTP are equivalent to three, two and one ATP, respectively.

a. 550 b. 600 c. 650 d. 700 e. 750

4 Acetyl-CoA produces one glucose. Ten glucose requires 40 acetyl-CoA. Since synthesis of one acetyl-CoA requires 20 ATP, Synthesis of 40 acetyl-CoA requires 800 ATP

2 Acetyl-CoA are converted to $\frac{1}{2}$ glucose through glyoxylate pathway and gluconeogenesis.

2 Acetyl-CoA ⟶ OAA + 2NADH + $FADH_2$

OAA + GTP + ATP + NADH ⟶ $\frac{1}{2}$ glucose

2 Acetyl-CoA ⟶ $\frac{1}{2}$ glucose + NADH

40 Acetyl-CoA ⟶ 10 glucose + 20NADH (= 60ATP) → Produced

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6. Assume that a C_3 plant can produce **ten** G6P using either the cyclic or non-cyclic pathways. Assume that one NADPH is produced from three ATP, but ATP is not produced from NADPH. How many photons are necessary for the most efficient synthesis?
a. 400 (b.) 450 c. 500 d. 550 e. 600

C_3-plant $CO_2 + 3ATP + 2NADPH \longrightarrow \frac{1}{6} G6P$

$60CO_2 + 180ATP + 120NADPH \longrightarrow 10\,G6P$

Non-cyclic: $8h\nu \longrightarrow 4ATP + 2NADPH$ (10ATP) ← better

Cyclic $8h\nu \longrightarrow \frac{16}{3} ATP$

$\frac{8\times(180+360)}{10} = \frac{8\times540}{10} = 432$

Proof:
432 $h\nu$ produce 216ATP and 108NADPH. (216 − 180 = 36ATP) produce 12 NADPH.

7. (cis $\Delta^{9,12,15}$ C_{24}) fatty acid is completely oxidized to CO_2 by β-oxidation and the citric acid cycle, and the produced CO_2 is converted to glucose using the enzymes in the dark reaction. How many moles of ATP are consumed from the fatty acid to glucose conversion? Assume that acetyl-CoA, propionyl-CoA, NADH, NADPH, and $FADH_2$ are equivalent to 12ATP, 20ATP, 3ATP, 3ATP and 2ATP, respectively.
a. 10 b. 15 c. 20 (d.) 25 e. 30

#C	#Acetyl-CoA	#β-oxidation	1st =	2nd =	3rd =	CoA-attach
24	12	11	1	1	1	1
	144	55	-2	-3	-2	-2
	144	199	197	194	192	190

190 ATP are produced.

$CO_2 + 3ATP + 2NADPH \longrightarrow \frac{1}{6}$ glucose.

$24CO_2 + 72ATP + 48NADPH \longrightarrow 4$ glucose.

$\frac{3}{2}$

$72 + 144 = 216$ ATP are required.

$\frac{24}{9}$
$\frac{}{6}$

$216 - 190 = 26$ ATP are consumed

8. Complete oxidation of **two** acetyl group in the citric acid cycle produces ____ pairs of electrons.
a. 3 b. 4 (c.) 8 d. 12 e. 16