Chapter One:

Basic Concepts

1.1 If 60 C of charge pass through an electric conductor in 30 seconds, determine the current in the conductor. **CS**

SOLUTION:

1.1 $Q = 60C$ $\Delta t = 30\,s$ $I = \frac{Q}{\Delta t} = \frac{60}{30}$ $\boxed{I = 2A}$

1.2 In an electric conductor, a charge of 300 C passes any point in a 5-s interval. Determine the current in the conductor.

SOLUTION:

1.2 $Q = 300\,C$ $\Delta t = 5s$ $I = \frac{Q}{\Delta t}$

$$\boxed{I = 60A}$$

1.3 The current in a conductor is 1.5 A. How many coulombs of charge pass any point in a time interval of 1.5 min?

SOLUTION:

1.3 $I = 1.5\,A$ $\Delta t = 1.5\,min = 90\,s$ $q = I(\Delta t)$ $\boxed{q = 135\,C}$

1.4 Determine the number of coulombs of charge produced by a 12-A battery charger in an hour.

SOLUTION:

1.4 $I = 12\,A$ $\Delta t = 1$ hour $= 60$ min $= 3600s$

$Q = I(\Delta t) = 12(3600)$ $\boxed{Q = 43.2\,kC}$

1.5 A lightning bolt carrying 20,000 A lasts for 70 μs. If the lightning strikes a tractor, determine the charge deposited on the tractor if the tires are assumed to be perfect insulators.

SOLUTION:

1.5 $I = 20{,}000\ A$ $\Delta t = 70\ \mu s$ $Q = I(\Delta t) = (20k)(70\mu)$

$$\boxed{Q = 1.4\ C}$$

1.6 If a 12-V battery supplies 10 A, find the amount of energy delivered in 1 hour.

SOLUTION:

1.6 $V = 12V \quad I = 10A \quad \Delta t = 1 \text{ hour} = 3600s$

$P = VI = 12(10) = 120W \quad W = P(\Delta t) = 120(3600)$

$\boxed{W = 432 \text{ kJ}}$

1.7 Determine the energy required to move 240 C through 6 V. **CS**

SOLUTION:

1.7 $Q = 240\ C$ $V = 6V$ $W = QV = 240(6)$ $\boxed{W = 1440J}$

1.8 Five coulombs of charge pass through the element in Fig. P1.8 from point *A* to point *B*. If the energy absorbed by the element is 120 J, determine the voltage across the element.

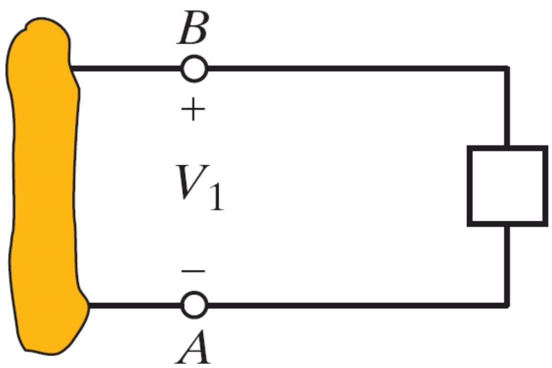
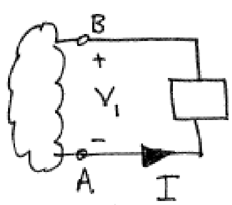


Figure P1.8

SOLUTION:

1.8



$Q = 5C$

$W = 120J$

For passive sign convention:

$W = -V_1 Q$ $\quad V_1 = -W/Q$

$\boxed{V_1 = -24V}$

1.9 The charge entering an element is shown in Fig. P1.9. Find the current in the element in the time interval $0 \leqq t \leqq 0.5$ s. [*Hint:* The equation for $q(t)$ is $q(t) = 1 + (1/0.5)t, t \geqq 0$.]

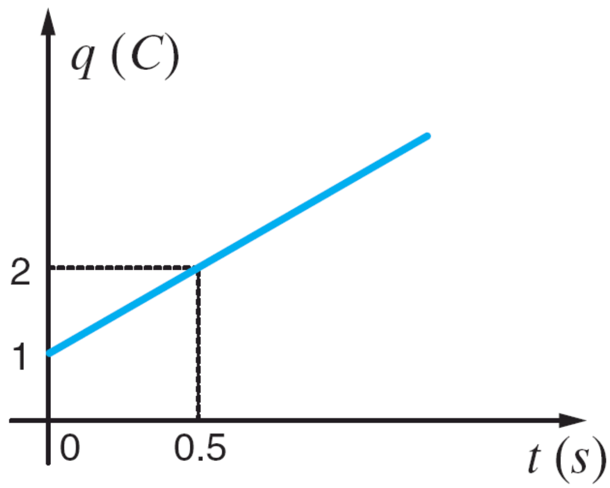


Figure P1.9

SOLUTION:

1.9 $0s \leq t \leq 0.5s$ $\quad q(t) = 1 + 2t$ $\quad i(t) = \frac{dq}{dt} = 2\ A$

$$\boxed{i(t) = 2\ A}$$

1.10 Determine the amount of power absorbed or supplied by the element in Fig. P1.10 if

(a) $V_1 = 9$ V and $I = 2$ A.

(b) $V_1 = 9$ V and $I = -3$ A.

(c) $V_1 = -12$ V and $I = 2$ A.

(d) $V_1 = -12$ V and $I = -3$ A.

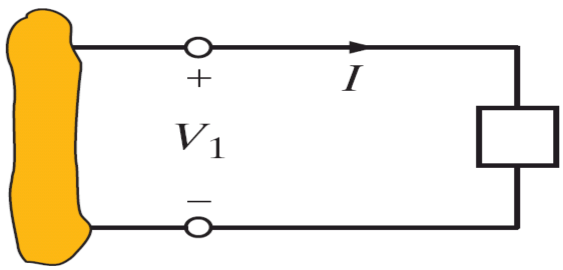
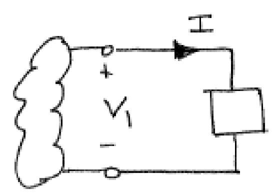


Figure P1.10

SOLUTION:

1.10 a) $V_1 = 9V$, $I = 2A$



For passive sign convention, $P = V_1 I$ is power absorbed.

$P = V_1 I = 9(2) = 18W$ absorbed

P = 18W absorbed

b) $V_1 = 9V$, $I = -3A$

$P = 9(-3) = -27W$

P = 27 W supplied

c) $V_1 = -12V$, $I = 2A$

$P = -24W$

P = 24 W supplied

d) $V_1 = -12V$, $I = -3A$

$P = +36W$

P = 36 W absorbed

1.11 Determine the magnitude and direction of the voltage across the elements in Fig. P1.11.

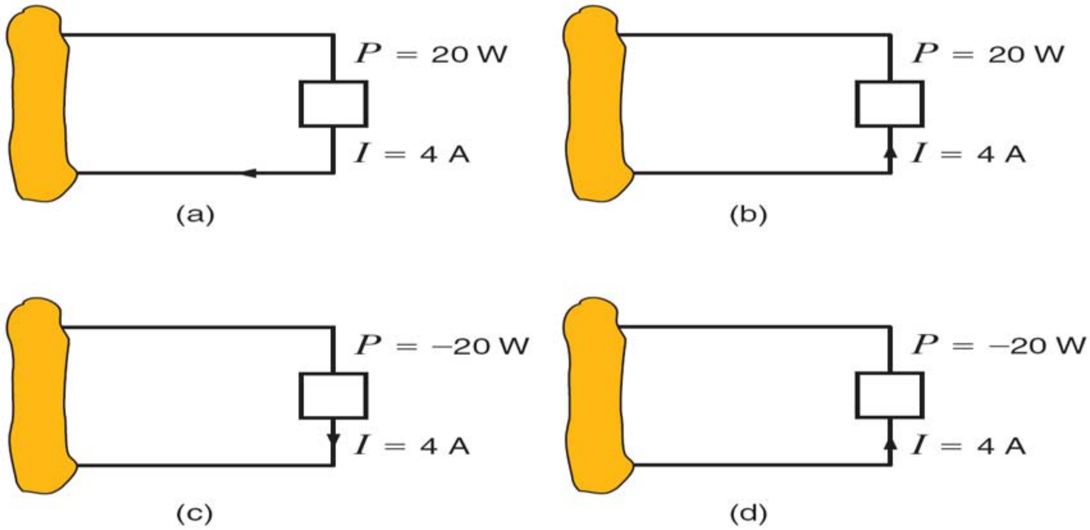
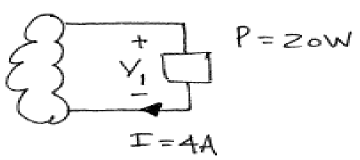


Figure P1.11

SOLUTION:

1.11 a)

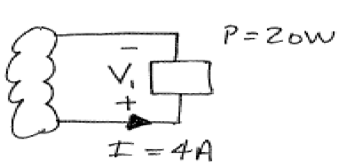


Passive sign convention

$P = VI$ $V = P/I = \frac{20}{4} = 5V$

$\boxed{V_1 = 5V}$

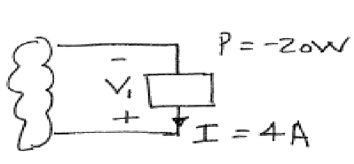
b)



$P = VI$ $V = P/I = \frac{20}{4} = 5V$

$\boxed{V_1 = 5V}$

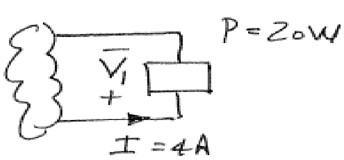
c)



$V = P/I = -5V$ {Element supplies power!!

$\boxed{V_1 = 5V}$

d)



same as part b).

$\boxed{V_1 = 5V}$

1.12 Determine the missing quantity in the circuits in Fig. P1.12.

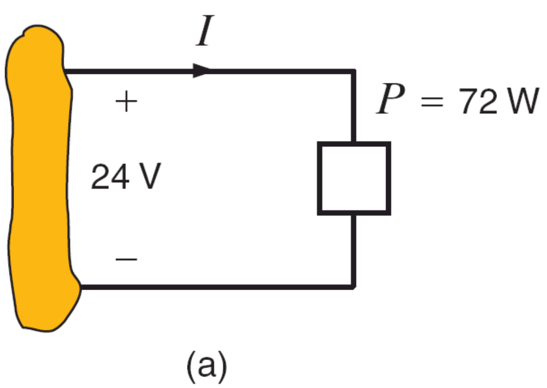
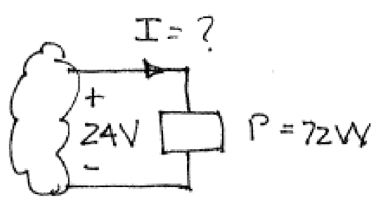


Figure P1.12

SOLUTION:

1.12 a)

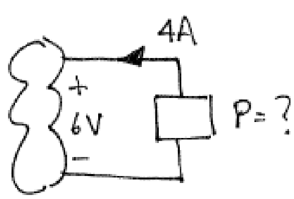


Passive sign convention

$P = VI$ $\quad I = P/V = 72/24 = 3A$

$I = 3A$

b)



V & I are in the active sign convention

$P = -VI = -(6)(4) = -24W$

P = −24W or 24W supplied

1.13 Determine the missing quantity in the circuits in Fig. P1.13.

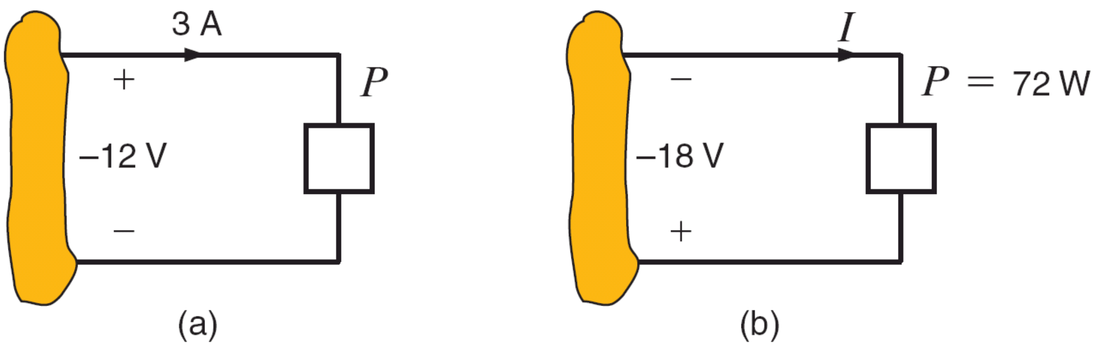
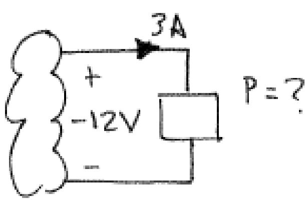


Figure P1.13

SOLUTION:

1.13 a)



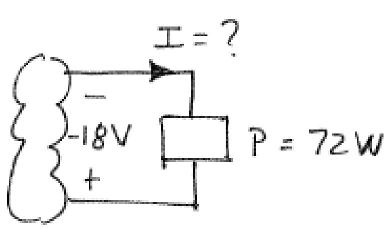
V & I are defined in passive sign convention

$P = VI = -36W$

Since P is negative, power is actually supplied

P = -36 W or 36 W supplied

b)



V & I defined in active sign convention

$P = -VI \qquad I = \frac{-P}{V} = \frac{-72}{-18}$

I = 4A

1.14 Determine the missing quantity in the circuits in Fig. P1.14. **CS**

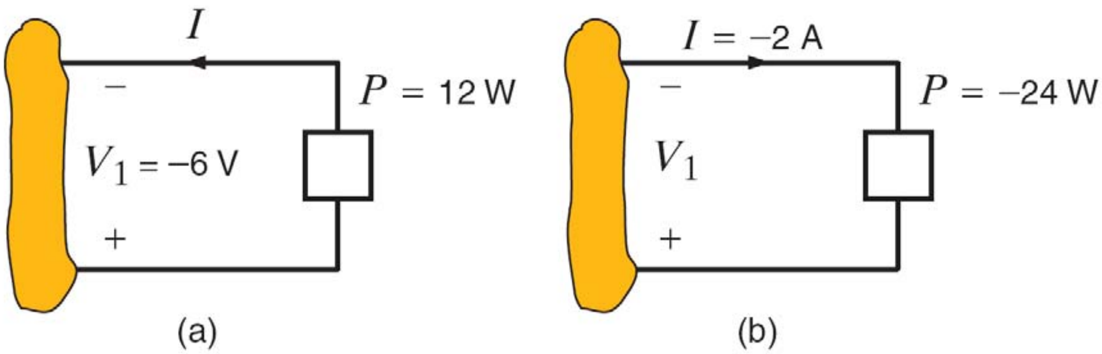
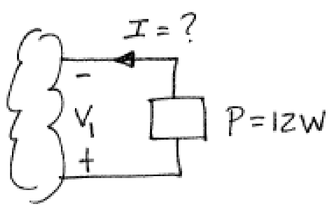


Figure P1.14

SOLUTION:

1.14 a)



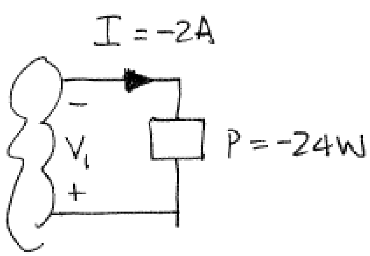
$V_1 = -6V$

V_1 & I defined as passive sign convention.

$P = V_1 I \qquad I = P/V_1 = \frac{12}{-6} = -2A$

$\boxed{I = -2A}$

b)



V_1 & I defined as active sign convention

$P = -V_1 I \qquad V_1 = -P/I = -\left[\frac{-24}{-2}\right] = -12V$

$\boxed{V_1 = -12V}$

1.15 Two elements are connected in series, as shown in Fig. P1.15. Element 1 supplies 24 W of power. Is element 2 absorbing or supplying power, and how much? CS

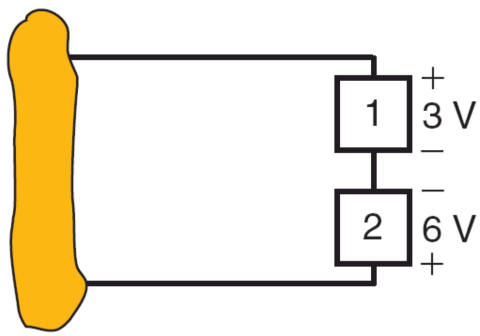
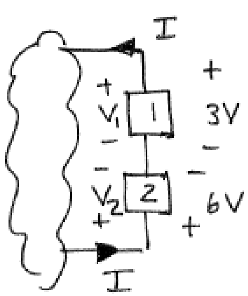


Figure P1.15

SOLUTION:

1.15



$P_1 = 24\text{W}$ supplied.

Using active sign convention for element 1

$P = V_1 I \Rightarrow I = P/V_1 = 8\text{A}$

(Note I is defined for active sign convention for element 1!)

In element 2, V & I are defined as passive sign convention.

$P_2 = V_2 I = (6)(8) = 48\text{ W}$

$$\boxed{P_2 = 48\text{W absorbed}}$$

1.16 Determine the power supplied to the elements in Fig. P1.16.

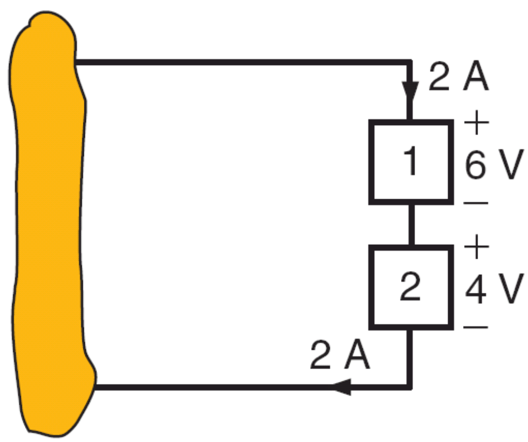
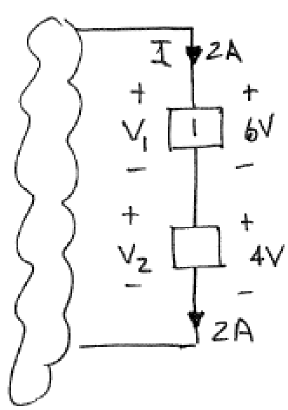


Figure P1.16

SOLUTION:

1.16



For element 1, V_1 and I are defined in passive sign convention. So, power supplied to the element is,

$$P_1 = +V_1 I = (2)(6) = 12W$$

$$\boxed{P_1 = 12W}$$

Element2 has V_2 & I defined in the passive sign convention also.

$$P_2 = V_2 I = (2)(4) = 8W$$

$$\boxed{P_2 = 8W}$$

1.17 Determine the power supplied to the elements in Fig. P1.17.

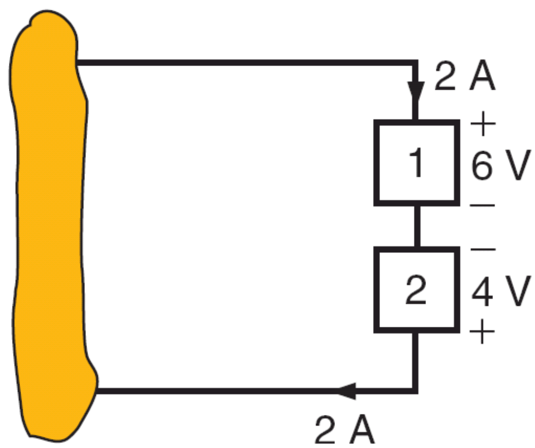
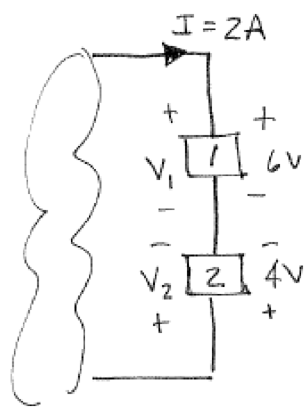


Figure P1.17

SOLUTION:

1.17



For element 1: V_1 & I are defined in the passive sign convention. So, power supplied to element 1 is,

$$P_1 = V_1 I = 6(2) = 12W$$

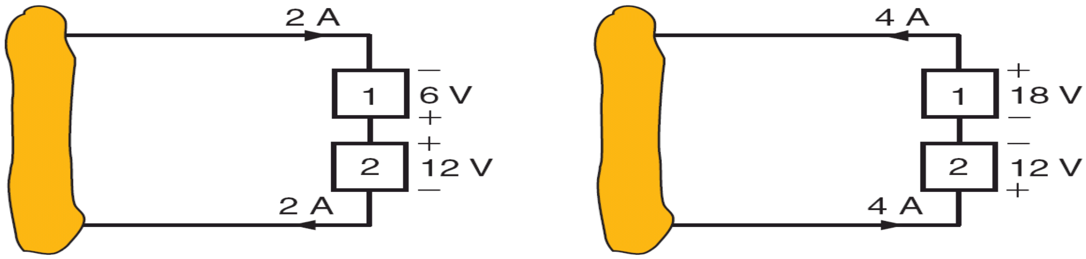
$$\boxed{P_1 = 12W}$$

For element 2: V_2 & I are defined in the active sign convention Power supplied to element2 is

$$P_2 = -V_2 I = -4(2) = -8W$$

$$\boxed{P_2 = -8W}$$

1.18 Determine the power supplied to the elements in Fig. P1.18.

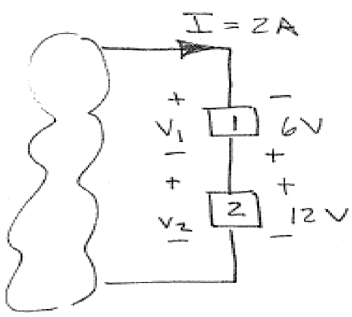


(a) (b)

Figure P1.18

SOLUTION:

1.18 a)



In both elements, voltages and currents are defined in passive sign convention.

For element 1, power supplied is

$P_1 = V_1 I = (-6)(2) = 12W$

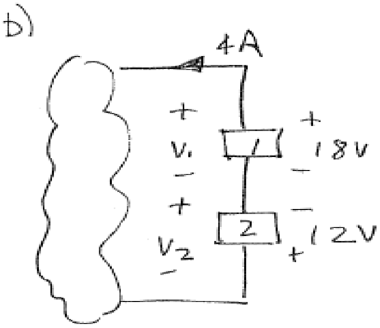
$\boxed{P_1 = 12W}$

For element 2,

$P_2 = V_2 I = 12(2) = 24W$

$\boxed{P_2 = 24W}$ absorbed

b)



In both elements, voltages and currents defined in active sign convention

For element 1: $V_1 = +18V$

$P_1 = -V_1 I = -(18)(4) = -72W$

$\boxed{P_1 = -72W}$ absorbed

For element 2: $V_2 = -12V$

$P_2 = -V_2 I = -(-12)(4) = +48W$

$\boxed{P_2 = 48W}$ absorbed

1.19 (a) In Fig. P1.19(a), $P_1 = 36$ W. Is element 2 absorbing or supplying power, and how much?

(b) In Fig. P1.19(b), $P_2 = -48$ W. Is element 1 absorbing or supplying power, and how much?

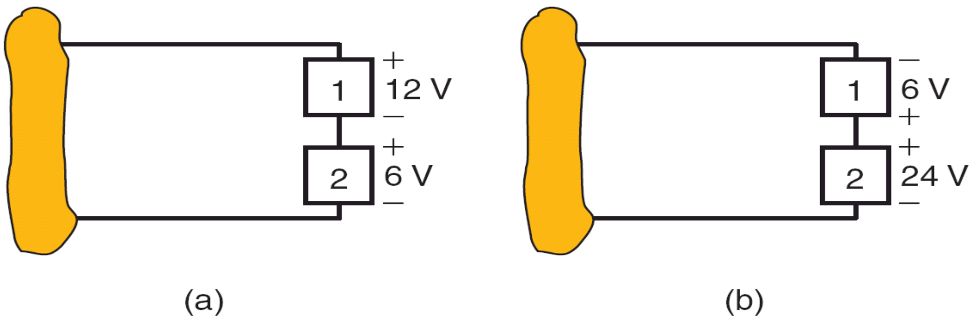
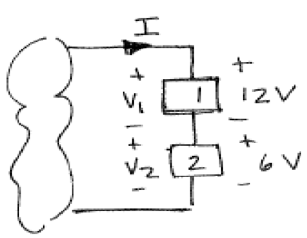


Figure P1.19

SOLUTION:

1.19a) $P_1 = 36W$



By default, using passive sign convention. Since P_1 is positive, I flows as shown on circuit diagram.

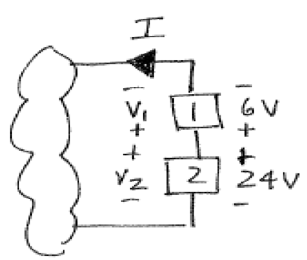
$P_1 = V_1 I \quad I = P_1/V_1 = 36/12 = 3\ A \quad I = 3A$

For element 2, V_2 & I are defined in passive sign convention,

$P_2 = V_2 I = 6(3) = 18W$

$P_2 = 18W$ absorbed

b) $P_2 = -48W$



Again, passive sign convention is the default. Since $P_2 < 0$, element 2 supplies power and I flows as shown.

$P_2 = -V_2 I = -24 I \quad I = -48/-24 = 2A$

For element 1, V_1 & I are defined in passive sign convention. Power absorbed is

$P_1 = V_1 I = 6(2) = 12W$

$P_2 = 12W$ absorbed

1.20 Two elements are connected in series, as shown in Fig. P1.20. Element 1 supplies 24 W of power. Is element 2 absorbing or supplying power, and how much?

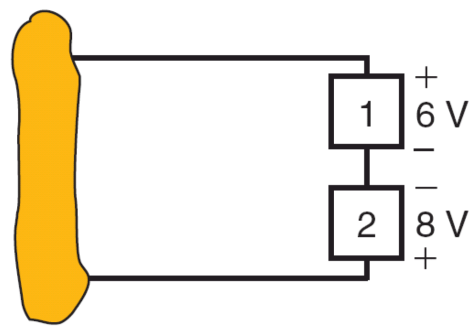
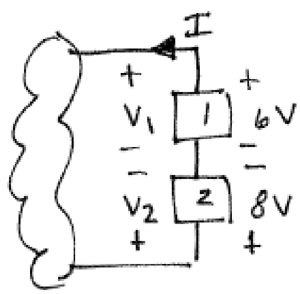


Figure P1.20

SOLUTION:

1.20 Element 1 supplies 24 W.



For element 1 supplying power, I must flow as shown.

$$I = P_1/V_1 = \frac{24}{6} = 4A$$

In Element 2, V_2 & I are defined as the passive sign convention power absorbed is

$$P_2 = V_2 I = 8(4) = 32W$$

$P_2 = 32W$ absorbed

1.21 Two elements are connected in series, as shown in Fig. P1.21. Element 1 supplies 24 W of power. Is element 2 absorbing or supplying power, and how much? **CS**

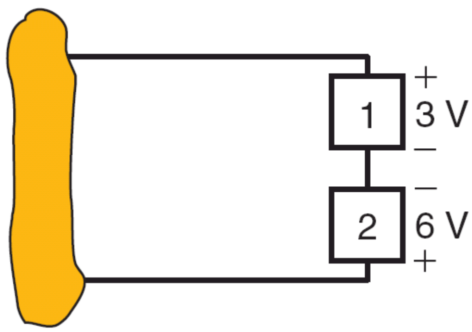
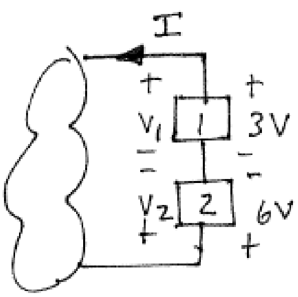


Figure P1.21

SOLUTION:

1.21 Element 1 supplies 24W. Since supplying power, I must flow as shown.



$$I = P_1 / V_1 = 24/3 = 8\ A \qquad I = 8A$$

For element 2, V_2 & I obey passive sign convention. Power absorbed is

$$P_2 = V_2 I = 6(8) = 48W$$

$P_2 = 48W$ absorbed

1.22 Two elements are connected in series, as shown in Fig. P1.22. Element 1 absorbs 36 W of power. Is element 2 absorbing or supplying power, and how much?

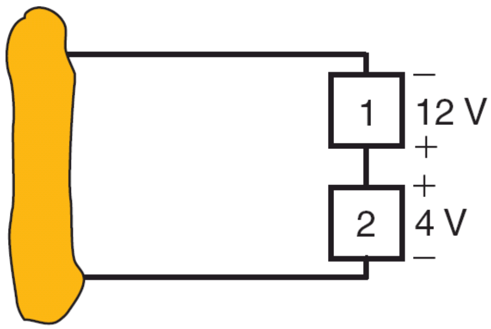
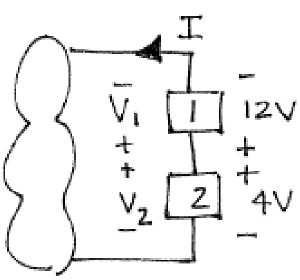


Figure P1.22

SOLUTION:

1.22 Element 1 absorbs 36 W. For absorbing power, I must flow as shown in the diagram.



$P_1 = V_1 I \qquad I = P_1/V_1 = 36/12 \qquad I = 3\text{ A}$

For element 2, V_2 & I are defined in active sign convention, Power supplied is

$P_2 = V_2 I = 4(3) = 12\text{ W}$

$P_2 = 12\text{ W}$ supplied

1.23 Determine the power that is absorbed or supplied by the circuit elements in Fig. P1.23.

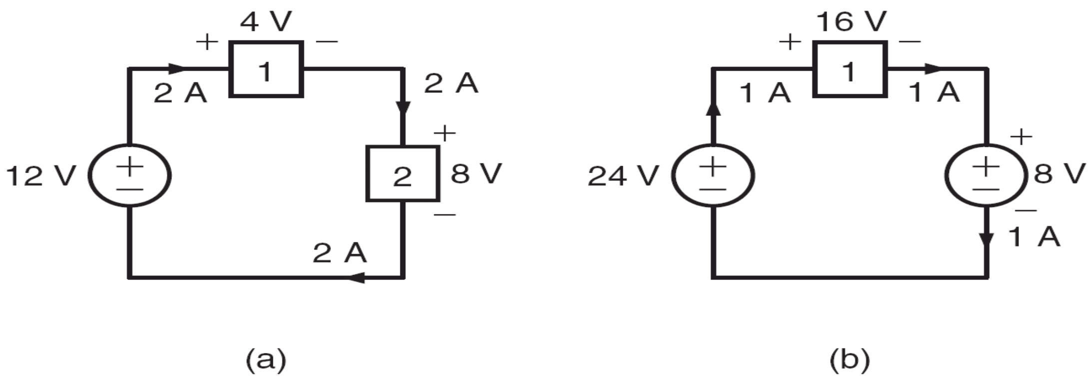
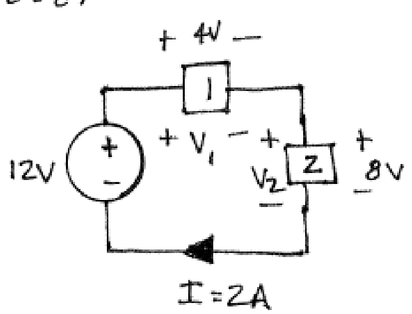


Figure P1.23

SOLUTION:

1.23 a)



Both element 1 and 2 voltages and currents are defined in passive sign convention.

$P_1 = V_1 I = 4(2) = 8\text{W}$ — **$P_1 = 8\text{W}$ absorbed**

$P_2 = V_2 I = 8(2) = 16\text{W}$ — **$P_2 = 16\text{W}$ absorbed**

Voltage source must supply sum $P_1 + P_2$ for power balance

$P_{12V} = P_1 + P_2 = 24\text{W}$ — **$P_{12V} = 24\text{W}$ supplied**

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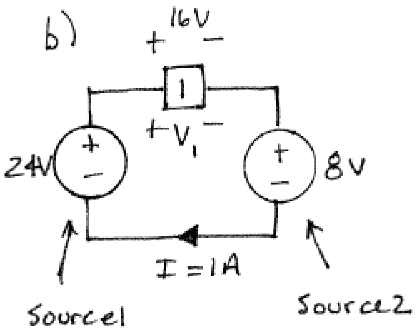
b)



V_1 & I in passive sign convention

$P_1 = V_1 I = 16(1) = 16W$ $\boxed{P_1 = 16W \text{ absorbed}}$

For source 1, V & I in active sign convention.

$P_{24V} = 24(1) = 24W$ $\boxed{P_{24V} = 24W \text{ supplied}}$

For source 1, V & I are defined in passive sign convention.

$P_{8V} = VI = 8(1) = 8W$ $\boxed{P_{8V} = 8W \text{ absorbed}}$

CHECK: for power balance, $P_{supplied} = P_{absorbed}$

$24 = 8 + 16 = 24$ ✓

$\Uparrow$

$P_{24V} = P_{8V} + P_1$

1.24 Find the power that is absorbed or supplied by the network elements in Fig. P1.24. **PSV**

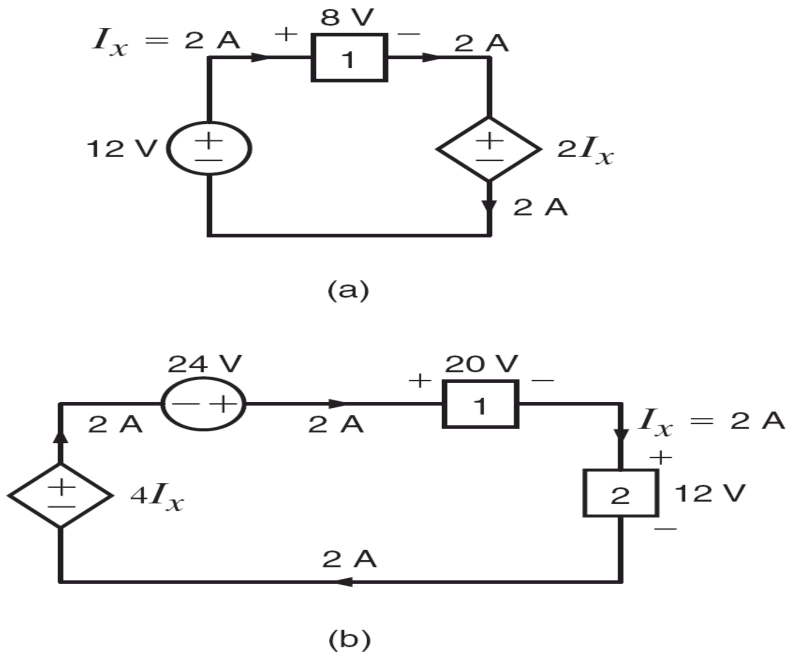
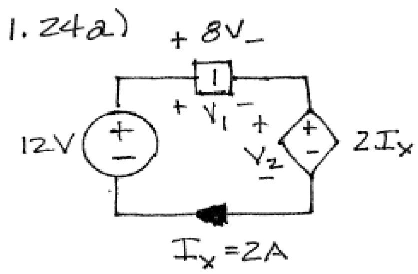


Figure P1.24

SOLUTION:



Voltages and currents for element 1 and for the dependent source are defined in the passive sign convention.

$P_1 = V_1 I_x = 8(2) = 16$ W

$P_1 = 16$W absorbed

$P_2 = V_2 I_x = (2I_x) I_x = 4(2) = 8$W

$P_2 = 8$W absorbed

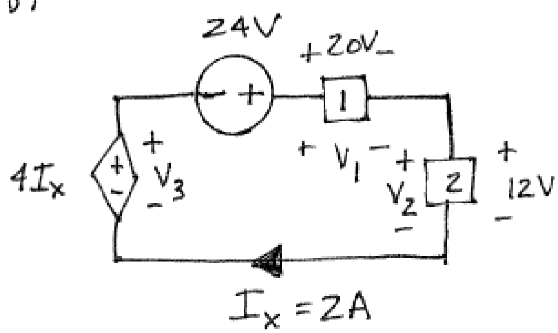
For the dependent source, V & I are defined in the active sign convention.

$P_{12V} = 12 I_x = 12(2) = 24$W

$P_{12V} = 24$W supplied

Continued on next page.

b)



V & I are defined in the passive sign convention for elements 1 and 2; and in the active sign convention in both the dependent and independent source.

$P_1 = V_1 I_x = 20(2) = 40W$

$P_2 = V_2 I_x = 12(2) = 24W$

$P_3 = V_3 I_x = 4I_x^2 = 4(2)^2 = 16W$

$P_{24V} = 24(I_x) = 24(2) = 48W$

$P_1 = 40W$ absorbed
$P_2 = 24W$ absorbed
$P_3 = 16W$ supplied
$P_{24V} = 48W$ supplied

1.25 Is the source V_S in the network in Fig. P1.25 absorbing or supplying power, and how much?

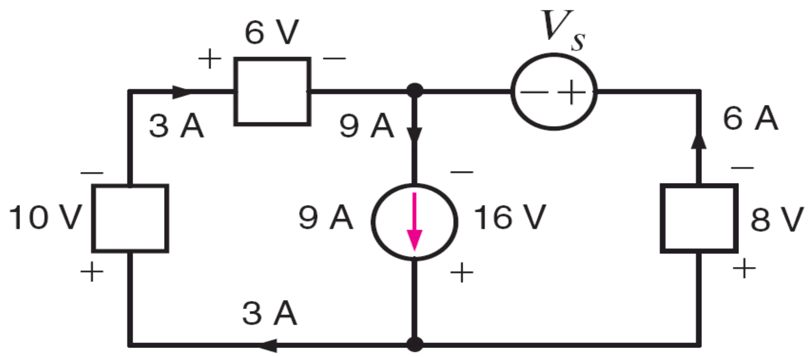
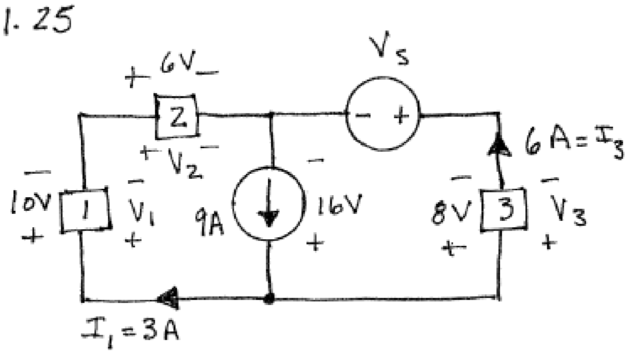


Figure P1.25

SOLUTION:

1.25



V & I for elements 1, 2, 3 defined in passive sign convention.

$P_1 = V_1 I_1 = 10(3) = 30W$ absorbed

$P_2 = V_2 I_1 = 6(3) = 18W$ absorbed

$P_3 = V_3 I_3 = 8(6) = 48W$ absorbed

Current source V & I defined in active sign convention

$P_{9A} = 9(16) = 144W$ supplied.

Power balance requires power supplied = power absorbed.
Assume V_S supplies power.

$P_{9A} + P_{V_S} = P_1 + P_2 + P_3 \Rightarrow 144 + P_{V_S} = 30 + 18 + 48 = 96W$

$P_{V_S} = -48W$

Since $P_{V_S} < 0$, V_S absorbs power

$\boxed{P_{V_S} = 48W \text{ absorbed}}$

1.26 Find V_x in the network in Fig. P1.26.

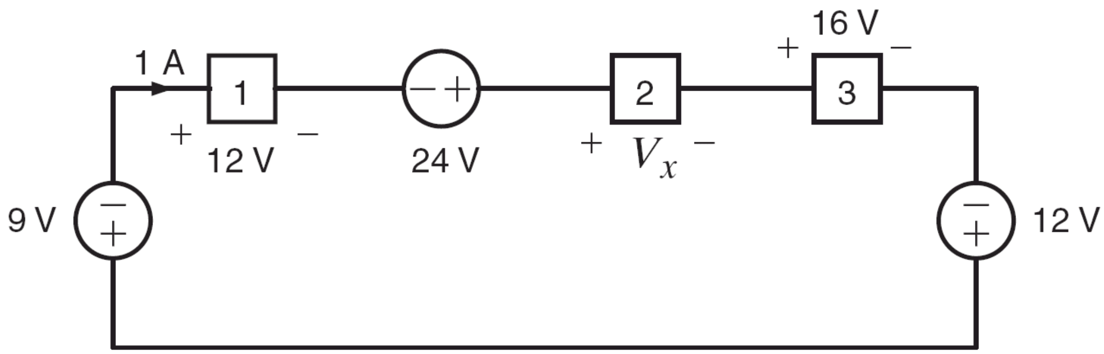
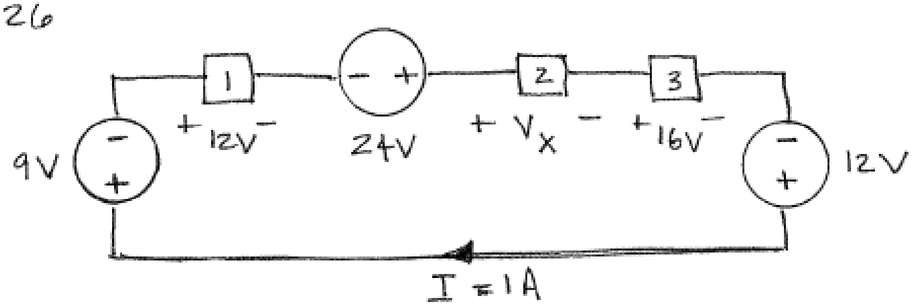


Figure P1.26

SOLUTION:

1.26



Passive sign convention: Elements 1, 2, 3 and 9-V source

Active sign convention: 24-V and 12-V source.

Power balance: $P_{24V} + P_{12V} = P_{9V} + P_1 + P_2 + P_3$

$$24I + 12I = 9I + 12I + V_x I + 16I$$

$$36 = 37 + V_x$$

$$\boxed{V_x = -1V}$$

1.27 Find V_x in the network in Fig. P1.27. **PSV**

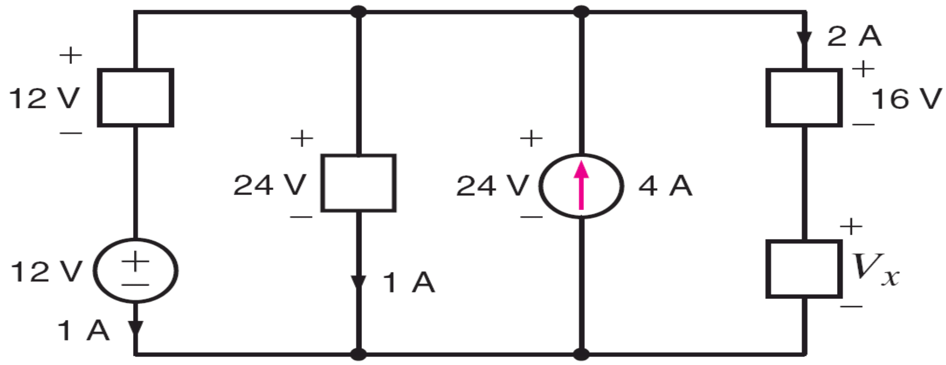
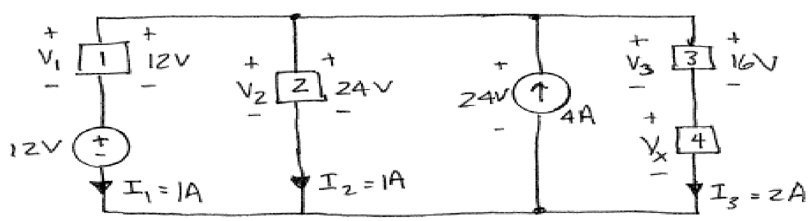


Figure P1.27

SOLUTION:

1.27



Passive sign convention: Elements 1, 2, 3, 4 and 12-V source.

$P_1 = V_1 I_1 = 12(1) = 12\,W$ $\qquad P_1 = 12\,W$ absorbed

$P_2 = V_2 I_2 = 24(1) = 24\,W$ $\qquad P_2 = 24\,W$ absorbed

$P_3 = V_3 I_3 = 16(2) = 32\,W$ $\qquad P_3 = 32\,W$ absorbed

$P_4 = V_4 I_3 = V_x I_3 = 2V_x$ $\qquad P_4 = 2V_x$ absorbed

$P_{12V} = 12(I_1) = 12(1) = 12\,W$ $\qquad P_{12V} = 12\,W$ absorbed

$P_{4A} = 24(4) = 96\,W$ $\qquad P_{4A} = 96\,W$ supplied

Power balance requires $P_{supplied} = P_{absorbed}$.

$$P_{4A} = P_{12V} + P_1 + P_2 + P_3 + P_4$$

$$96 = 12 + 12 + 24 + 32 + 2V_x$$

$$\boxed{V_x = 8\,V}$$

1.28 Compute the power that is absorbed or supplied by the elements in the network in Fig. P1.28. **CS**

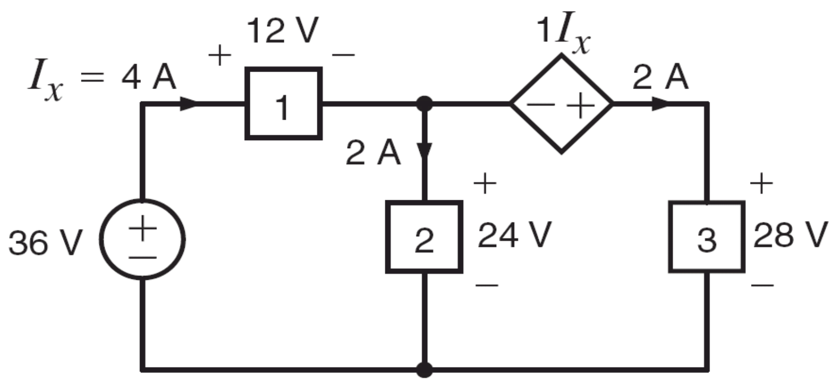
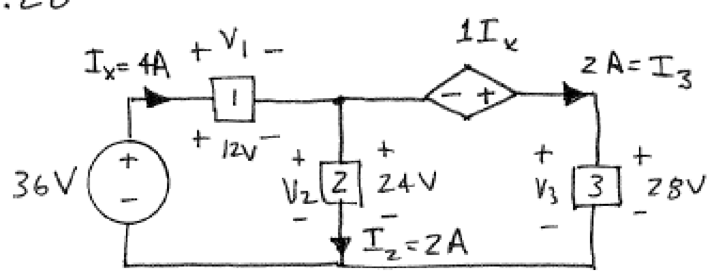


Figure P1.28

SOLUTION:

1.28



Passive sign convention?

Element 1, 2, 3.

$P_1 = V_1 I_x = 12(4) = 48\,W$

$P_1 = 48\,W$ absorbed

$P_2 = V_2 I_2 = 24(2) = 48\,W$ — $P_2 = 48\,W$ absorbed

$P_3 = V_3 I_3 = 28(2) = 56\,W$ — $P_3 = 56\,W$ absorbed

$P_{36V} = 36 I_x = 36(4) = 144\,W$ — $P_{36V} = 144\,W$ supplied

$P_{D.S.} = (1 I_x) I_3 = 4(2) = 8\,W$ — $P_{D.S.} = 8\,W$

1.29 Find I_o in the network in Fig. P1.29. CS

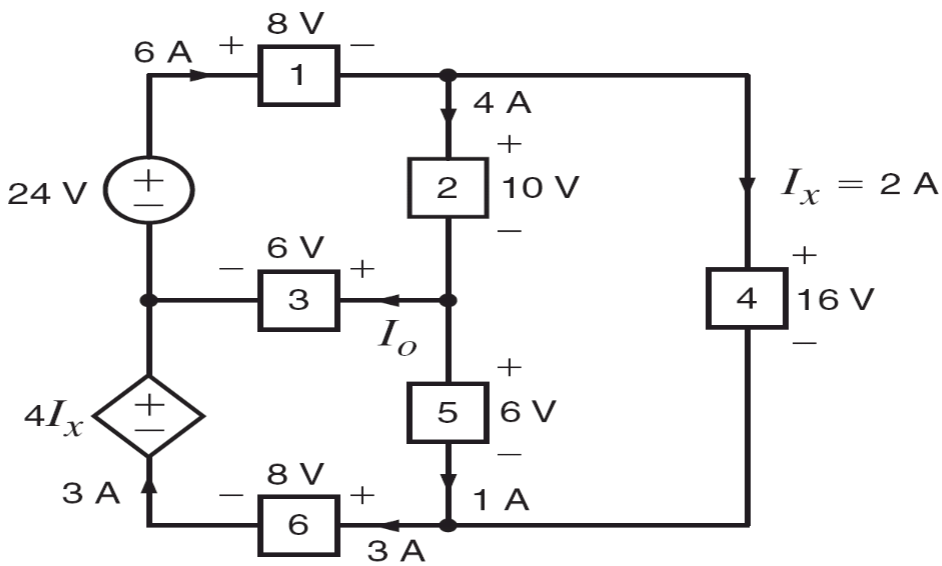
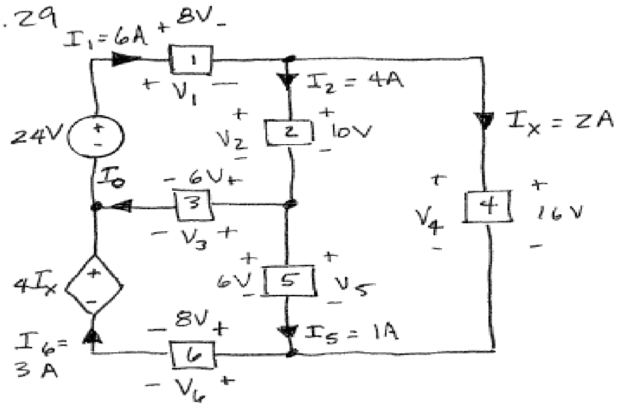


Figure P1.29

SOLUTION:

1.29



Passive sign convention:

Elements 1, 2, 3, 4, 5.

$P_1 = V_1 I_1 = 48\text{ W}$ absorbed

$P_2 = V_2 I_2 = 40\text{ W}$ absorbed

$P_3 = V_3 I_o = 6 I_o$ absorbed

$P_4 = V_4 I_x = 32\text{ W}$ absorbed

$P_5 = V_5 I_5 = 6\text{ W}$ absorbed

$P_6 = V_6 I_6 = 24\text{ W}$ absorbed

$P_{24V} = 24 I_1 = 144\text{ W}$ supplied $\qquad P_{4I_x} = 4I_x I_6 = 24\text{ W}$ supplied

$$P_{supplied} = P_{absorbed}$$

$$P_{24V} + P_{4I_x} = P_1 + P_2 + P_3 + P_4 + P_5 + P_6$$

$$168 = 48 + 40 + 6I_o + 32 + 6 + 24$$

$$\boxed{I_o = 3\text{ A}}$$

1.30 Find I_x in the circuit in Fig. P1.30.

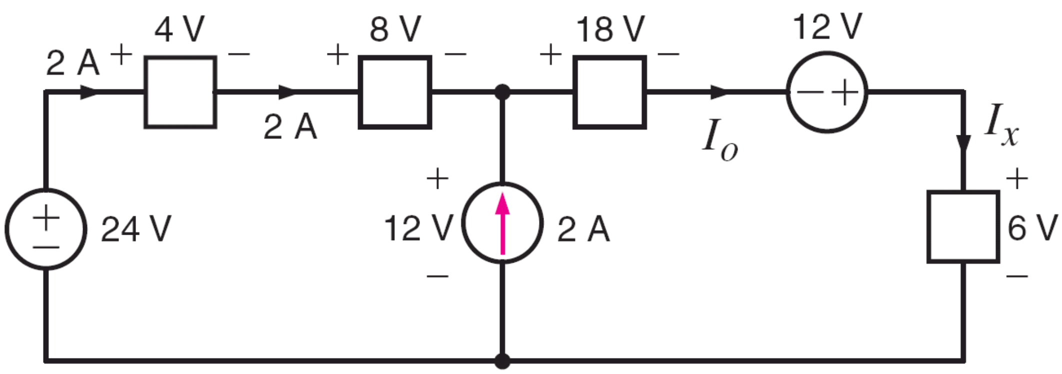
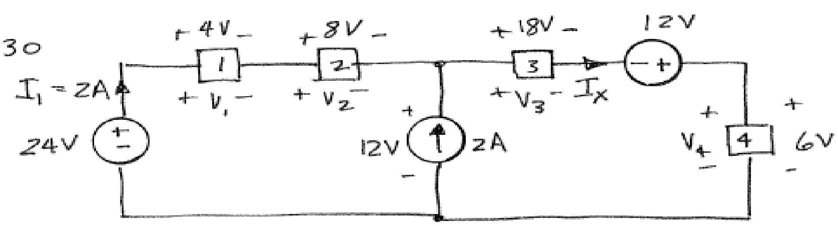


Figure P1.30

SOLUTION:

1. 30



Passive Sign Convention: Elements 1, 2, 3, 4

$P_1 = V_1 I_1 = 8W$ absorbed $\qquad P_2 = V_2 I_1 = 16W$ absorbed

$P_3 = V_3 I_x = 18 I_x$ absorbed $\qquad P_4 = V_4 I_x = 6 I_x$ absorbed

$P_{24V} = 24 I_1 = 48W$ supplied $\qquad P_{2A} = 12(2) = 24W$ supplied

$P_{12V} = 12 I_x$ supplied

$P_{supplied} = P_{absorbed}$

$P_{12V} + P_{24V} + P_{2A} = P_1 + P_2 + P_3 + P_4$

$12 I_x + 48 + 24 = 8 + 16 + 18 I_x + 6 I_x$

$48 = 12 I_x$

$\boxed{I_x = 4A}$

1.31 Find V_x in the network in Fig. P1.31.

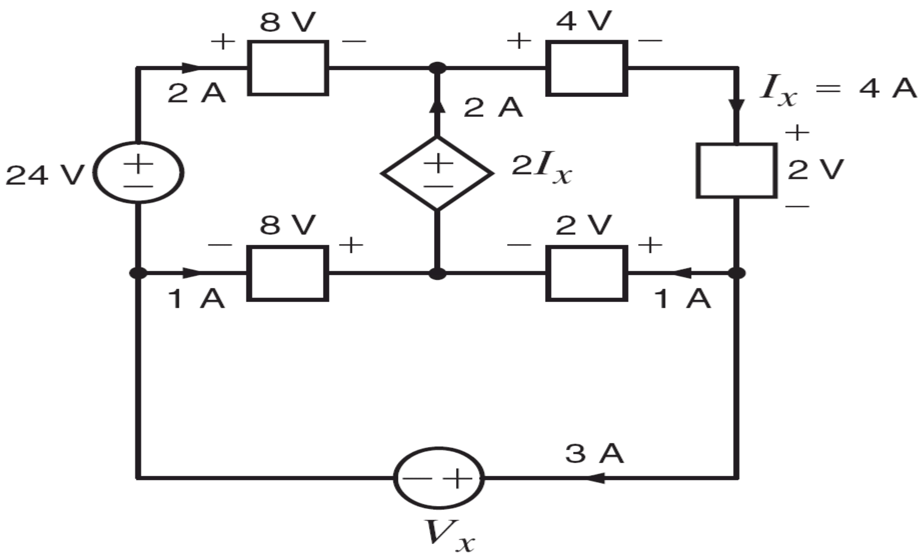
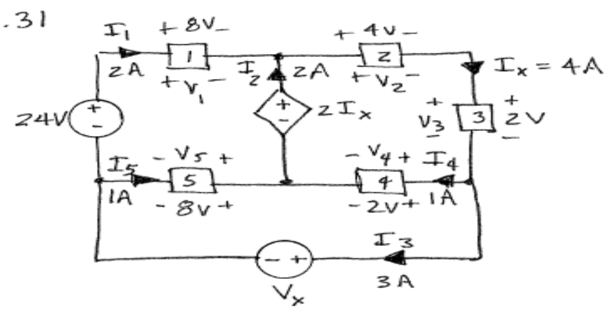


Figure P1.31

SOLUTION:

1.31



Passive sign convention:

Elements 1, 2, 3, 4, V_x

$P_1 = V_1 I_1 = 16$ W absorbed

$P_2 = V_2 I_x = 16$W absorbed

$P_3 = V_3 I_x = 8$ W absorbed

$P_4 = V_4 I_4 = 2$W absorbed

$P_{V_x} = V_x I_3 = 3V_x$ absorbed

$P_{24V} = 24 I_1 = 48$ W supplied $\quad P_5 = V_5 I_5 = 8$W supplied

$P_{2I_x} = 2I_x I_2 = 16$ W Supplied

$P_{supplied} = P_{absorbed}$

$P_{24V} + P_5 + P_{2I_x} = P_1 + P_2 + P_3 + P_4 + P_{V_x}$

$48 + 8 + 16 = 16 + 16 + 8 + 2 + 3V_x$

$$\boxed{V_x = 10V}$$

1.32 Find I_s such that the power absorbed by the two elements in Fig. P1.32 is 24 W.

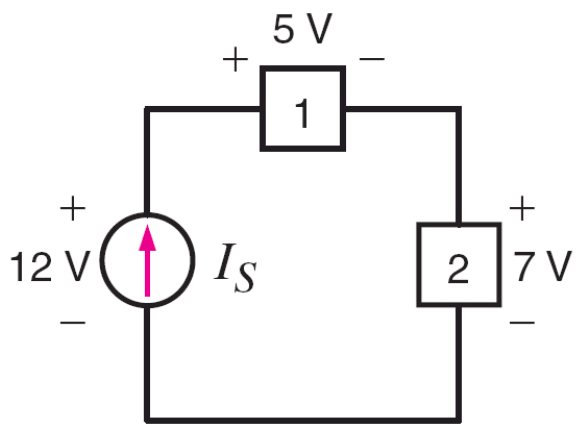
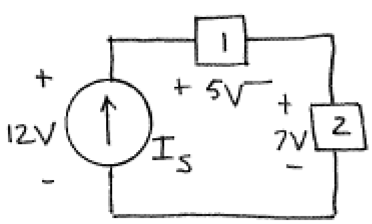


Figure P1.32

SOLUTION:

1.32



$P_1 + P_2 = P_{I_S} = 24\text{W}$

$P_{I_S} = 12(I_S) = 24$

$\boxed{I_S = 2\text{ A}}$